UKRAINIAN REGIONAL AIRPORTS: ADDED VALUE TO REGIONAL ECONOMIC DEVELOPMENT OR WASTE OF MONEY

by

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Abstract

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The last 5 years are marked by tremendous growth in the aviation sector of Ukraine. The increasing competition on the market due to the Visa-Free regime with the EU and change in a regulatory environment led to more than double passenger volumes in comparison with 2014. Not surprisingly that such a prosperous industry attracts a lot of attention from the Government, which considers the air-transportation sector as a significant tool of development of regional economies and, consequently, adopted the program aimed at sufficient developing and restoring of airport's infrastructure. Such a program, in turn, requires a great number of investments both from the state budget and from the private sector. This paper aims to investigate whether the air-traffic is indeed a facilitator of economic growth of the regions and such expenditures are truly justified or the relationship between these two values has a reverse or even two-way causality. Also, by applying region-fixed effect and two-stage least square (2SLS) models the particular effect of air-transportation on regional economies was determined. The results of this study support that increasing air-traffic frequency has a positive effect on regional economic growth, but the presence of this effect is positively connected with the volumes of its traffic.

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GLOSSARY

AIC. Akaike Information Criterion

ATO. Anti-Terrorist Operation

BIC. Bayesian Information Criterion

CPI. Consumer Price Index

EU. European Union

FPE. Final Prediction Error Criterion

GDP. Gross Domestic Product

HQC. Hannan-Quinn Information Criterion

IATA. International Air Transport Association

LCC. Low-Cost Carrier

OLS. Ordinary Least Square

PAX. Airline Passengers

PPI. Production Price Index

PWC. PricewaterhousCoopers

SAS. State Aviation Service

SSS. State Statistical Service

TFP. Total Factor Productivity

2SLS. Two-Stage Least Square

Chapter 1

INTRODUCTION

Well-developed transport infrastructure is one of the crucial components that contributes to the economic growth and development of a country, by providing the effective, quality and uninterrupted transport links between all its regions. The aviation sector is representing one of the pillars of this infrastructure. It is commonly believed that airports are an important factor in realizing the economic potential of the region. Through the supply-side, the airports increase the accessibility of the region and facilitate economic development and, in particular, the level of employment in the adjacent industries.

At the present time, Ukraine has been experiencing an unprecedented industry boom. The average growth rate of the passenger's traffic is estimated to be 24% for the last 4 years (see Figure 1).

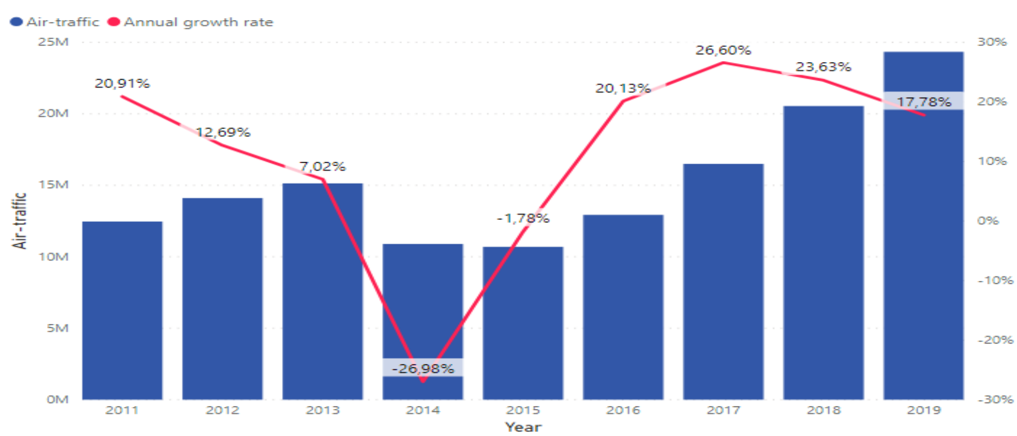

Figure 1. Dynamics of air-traffic flows in Ukraine for last 10 years[1]

[1] Source of data: *State Aviation Service*

There are a few reasons for such tremendous industry growth: sustained interest to Ukraine, launching the great number of new destinations by Ukrainian and foreign airlines (in 2018 Ukraine got among the top-20 countries by the number of new-opened flights), visa-free regime with EU and overall improving in the regulatory field which attracted a big number of LCC carriers and, consequently, the gradual revival of domestic airports (see Figure 2). All these indicate the fact that there is a growing number of Ukrainians that can afford the comfort of air travel. Against this background, the Ministry of infrastructure is considering the development of the aviation industry as one of its main priorities. Due to this goal in March 2016, the Ministry developed the Concept of the State target program for the development of airports for the period till 2023 and indicated in this strategy that each region must have its own airport.

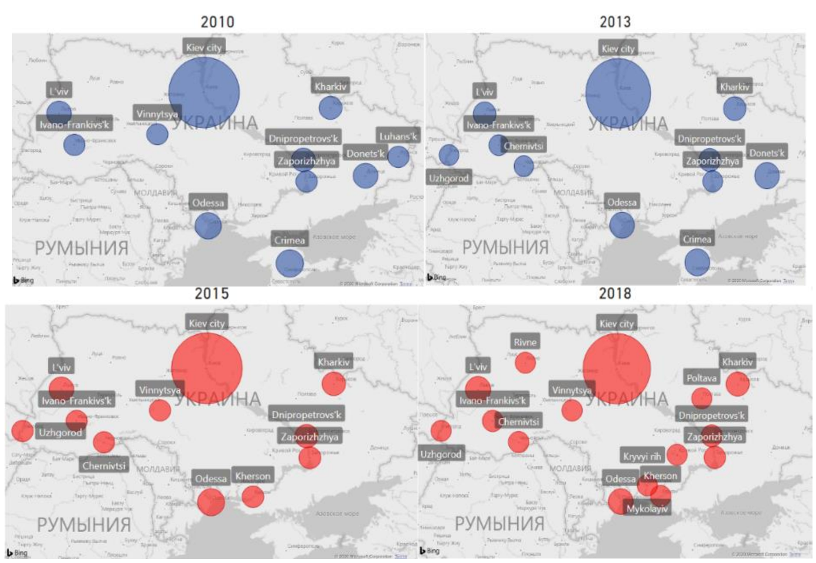

Figure 2. Number of functioning airports in Ukraine (before and after 2014)[2]

[2] Source of data: *State Aviation Service*

Currently, about 13 - 19 airports are considered to be constantly functioning in Ukraine, depending on the economic and political situation in the region and in the country overall, and their number has significantly increased in the last 5 years after the drastic decreasing in 2014 due to Crimea annexation and military conflict in Donbas region.

The main problems that these airports face are technological obsolescence and low bandwidth of terminal complexes that are not adapted to the latest technologies and not accessible to low-mobility groups. To improve the airport infrastructure, the Government has assigned 8.6 bln UAH, out of which 5 bln UAH are the state budget funds and the rest of the amount is an investment, which is directly guaranteed by the Government. Another ambitious goal of the Government is to restore all 50 airports in Ukraine till 2030 (Ukraine. Ministry of Infrastructure, Air-transport 2018). Such global task requires attracting even more investments, because the majority of regional airports are in a very poor condition and are not operated since 90's. In this context, the question of the relevance of such expenditures is arising. And to answer this question one needs to figure out how exactly the regional airports affect the development of their regions and whether they have any effect at all.

In this paper, we want to contribute to the literature on estimating the effects of air transportation on regional development by investigating the case of Ukraine. The specific task of this study is not only to determine the existence of causality between these two values but also to estimate what particular effect the expanding of air activity in Ukraine has on the development of the regions where the airports are located. To the best of our knowledge this paper is the first one that investigates this relationship in the country with such low airport density and the first study on some considered airports that resumed after a zero-traffic due to their inactiveness for a long time.

In order to estimate the impact of air activity on regional development, we follow the approach of Mukkala and Tervo (2013) who estimated the causal relationship by using Granger non-causality framework in panel framework and extending it by adding the regression analysis for quantifying the air activity impact. For this purpose, the Instrumental variable approach in fixed effect specification is applied which is adopted to capture the heterogeneity of the airports of different sizes and to deal with the endogeneity of the air-traffic measure. As the theoretical base for this estimation the studies of Lakew and Bilotkach (2017), Baltaci and Akbulut (2015) and Ozcan (2012) were used. We use the monthly panel data of air passenger traffic and the measurement of economic development for the last ten years. To investigate the causality relationship this measurement is represented by data on GDP per capita, and in the regression analysis we control for such variables such as educational level, population and capital investments.

During the research we got quite valuable and consistent with the literature results. The causality is indeed present for these two factors but its nature differs for relatively large and small airports. In particular, we find that in case of large airports the causality goes in two directions, from passenger's volume to GDP per capita and vice versa, while for small airports it goes only in one way, from air-traffic to GDP per capita, but not in the other one. The regression analysis, after addressing the endogeneity issue, shows robust and significant effect of increasing in air-traffic volumes on regional GDP. The positive impact was found for the sample of all investigated regions and for subsample with the largest ones, but was not found for subsample of small regions. Despite on its unexpected outcome, the findings are in line with the similar studies. In general, based on the results we can state that the catalytic impact, which airports can produce for their regions is positively depends on the volumes of their traffic, in other words it's mean that the amounts of traffic in small airports are simply not enough to generate this impact (Breidenbach, 2019), and this is the main outcome on which the policy response should be made. The main goal of the government policy should not only be in the increasing the number of airports in Ukraine, but to be assure that these airports could be able to generate appropriate amount of traffic and indeed be the value added to the region.

The paper is structured as follows: the first two chapters give the introduction and literature review. The third chapter describes the models and methodologies to be applied in order to conduct causality test and regression analysis and get the robust estimations. The fourth chapter demonstrates the data used for this analysis and the last two chapters discuss the obtained results and corresponding conclusions.

Chapter 2

LITERATURE REVIEW

The papers which are devoted to the investigation of the connection between airport infrastructure development and regional economic development are one of the most popular in the transportation economics field. Mostly, there is a consensus within the academic circles concerning the sign of this connection. It is usually assumed by most scholars to be positive, the only question that arises in a number of works is about the issue of two-way causality. In other words, whether the economic development of regions contributes to corresponding development of airports due to increasing demand on air transportation or the airports, they are the main drivers of economic development due to their contribution to increasing accessibility to the other markets and also facilitating the process of investment and movement of the workers between the regions. The latter statement is more common in general. Brathen et al. (2006) in the research on the investigation of the link between air transport and employment in Norway emphasize the importance of air transport activity for the country and especially for its remote regions. Due to its utilization of primary resources such as labor and capital, the air transport industry has its own impact on resource allocation as well as for value-added and income that consequently generate overall economic impact for the regions. Forsyth (2007) in his cost-benefit analysis of regional airport subsidy points out the argument of the economic impact of airports on the regions through increasing business activity and tourism inflow as the main justification of the subsidies to the airports. One of the exceptions of this common approach is PWC (2017) that analyses the relationship between the GDP and air traffic demand for the UK and Australia. Essentially, they find a strong relationship between these two variables, moreover, they investigate the responsiveness of air passengers demand to the change of GDP for the largest airports in the UK and Australia. In particular, the elasticity of air passengers demand for the busiest airport in the UK, Heathrow, is estimated to be 0.7% for each 1% change in the GDP level, the elasticity of the busiest Australian airports, Melbourne and Sydney, is found to be much higher – 1.7 and 1.8% respectively.

Cooper and Smith (2005) in their study develop the methodology to estimate the so-called "economic catalytic impact of air transport on economic development. Initially, they emphasize on five channels through which air transport affects the economy. These channels include: direct impacts (contribution to employment and activity in aviation sector), indirect (contribution to employment in adjacent industries to the aviation sector), induced impacts (direct spending of those who are employed in the aviation and adjacent sectors), consumer welfare impacts due to increasing travel availability and environmental impact. They use the "Equilibrium Correction Mechanism (ECM)" in order to estimate the relationship between air transport and business investment with TFP. Their results show a strong positive relationship, reflected in the estimated models.

InterVistas Consulting Group (2015) uses the methodology from Cooper and Smith (2005) paper in their own report which describes the economic impact of European airports. They also distinguish the main channels of impact but they go much further in estimating the casual relationship. By using the measure of connectivity developed by IATA and GDP per capita for 40 countries together with Granger causality framework they examine the issue of causality. The outcome of the causality analysis shows the two-way relationship, in other words, "there was statistically significant evidence that connectivity causes GDP growth per capita and that GDP per capita growth Granger-causes connectivity". Also, the quantitative effect of connectivity on GDP per capita was estimate using the OLS model by controlling different factors that can make an impact, such as education level, R&D spending, and institutional and regulatory factors.

Baltaci and Akbulut (2015) also quantify the impact of airports on regional economy for Turkey. They make an analyzing by using three different methods: Least Squares method, Fixed Effect model and Two Stage Least Squares method with Instrumental Variable approach. In all three methods they find highly significant and positive relationship between these two variables. In particular, Least Squares method shows that, holding everything else fixed, 1% increasing in a region's airline traffic per capita causes 0.021% increase in GDP per capita. Fixed Effect model, in turn, shows that 1%-point increase in the airline traffic per capita causes the increase in GDP at a rate of 0.0025%, and the Two Stage Least Squares method shows that 1% point increase in the airline traffic per capita causes the increase in GDP at a rate of 0.017%.

The Granger causality analysis is one of the most frequently used in addressing the existence of causality. Baker, Merkert, and Kamruzzaman (2015), for example, examine the causality between regional aviation and economic growth in Australia from 1985-86 to 2010-11. They conclude that airports have a direct impact on regional economic growth and the economy directly impacts regional air transport. They find evidence of the economic significance of the airport's infrastructure for regional development and recommend the regional councils to increase the funding of local airports. Mukkala and Tervo (2013) estimate the causality in the relationship between regional development and transportation infrastructure for 86 regions and 13 countries by using Granger non-causality analysis in a panel framework. This model specification allows authors to address such important issues as "potential heterogeneity, in which a causal relationship may be present only in a subset of cross-sections but not in the others". In general, they find that air transportation causes economic growth only in relatively remote regions, while for the core regions no causality is observed. Vijver, Derudder, and Witlox (2016) conduct similar research. They use the data of European NUTS2-regions in the context of air passenger transport and regional development and by applying to them a heterogeneous Granger causality model. As an Instrumental variable for regional development, the authors use the employment rate. The results show that causality occurs among the urban regions in Europe but at the same time "albeit very geographically fragmented". Yao and Yang (2008) use the Engel-Granger's two-step error correction model and the generalized error correction method in order to examine the causality for China. They find that economic growth and openness measured by the trade/GDP "have a positive and significant impact on air transport in all model specifications." Gibbons and Wu (2017) represent a more recent study for China's case. They conclude that airports positively affect local economic performance. The improved population access to airports increased industrial output and GDP with an elasticity of around 0.25. Percoco (2010) estimates the elasticity of service-sector employment to airline traffic, he finds it to be about 0.056 without and 0.045 with spatial spillover effect of airport development.

Florida, Mellander, and Holgersson (2015) in their paper examine the role of airports in regional development based on cross-section data of American airports. They use two OLS model in the research, first one is for determining the factors that influence the presence of airports in a big metro, and the second one examines their effect of having an airport on economic development. They conclude that airports add significantly to regional economic development measured as output per capita when controlling for regional characteristics.

The US data is utilizing in a number of other studies, one of which is Bilotkach (2015) research in which the positive effect of air traffic on employment and average wage but not on the number of establishments. Brueckner (2003) receives alike results. He emphasizes the importance of airline traffic on the service sector and evaluates that a 10% increase in passenger flow leads to a 1% increase in employment in service-related industries. Meanwhile, the no effect on manufacturing and other goods related-employment is found. Lakew and Bilotkach (2014) through evaluating the cost of airport delays on local employment prove the significance of good functioning airport infrastructure for local development. In particular, they find that a 10% increase in the number of delays flights leads to 0.15% decrease in total service-sector employment and to 0.7% decrease in good-producing jobs employment.

Relatively few papers find no causality in the relationship between airport activity and local development. One of each is Breidenbach's (2019) paper which investigates the Germany case. He concludes that "there's no evidence that the expansion of regional airports in Germany generated regional growth" also he finds that no spillover effect is spreading out from that expansion.

In this paper, we want to contribute to the existing literature by investigating the causality and effect of air activity and regional development for Ukraine. First of all, to the best of our knowledge is the first paper that will investigate the country with so low airport density and the second is that lot of these airports resumed their activeness in last 5-10 years, so it basically provides the opportunity to estimate the effect of airport expansion starting from zero passenger's traffic.

Chapter 3

METHODOLOGY

The empirical analysis of the research question was conducted by utilizing two approaches. The first one is the determining of causality links between air-traffic and GDP per capita. We follow Mukkala and Tervo (2013) to find these relationships. For the regression analysis, we follow the approach similar to that one used in Baltaci and Akbulut (2015), Ozcan (2012) and Lakew and Bilotkach (2017) papers. The main goal of the regression analysis was to define what particular effect air transportation's dynamic has on the GDP per capita for a different sample of regions. First of all, the effect was determined for the whole investigated sample of cities, after that the sample was divided into two subsamples: the first one is the sample of the largest cities which have well-established airports with highest volumes of passengers traffic; the second subsample consists mostly of small cities which have relatively much smaller volumes of traffic.

3.1. Causality analysis

A standard tool used in econometrics to evaluate the nature of the relationship between the two series is the Granger-causality technique. The essence of this technique is as follows: if we have two series **x** and **y**, the variable **x** is said to cause the variable **y** if the prediction of the variable **y** is determined based on its own past values and on the past values of the variable **x**, (Granger, 1969). The null hypothesis that is evaluating by this technique that **x** doesn't cause **y**. It is defined by regressing the lagged value of **y** and **x** on the present value of **y**, and if one of the estimated coefficients on the any lagged value of $\mathbf{x}$ is turned out to be significant than we reject the null hypothesis and make the conclusion about causality existence.

Mukkala and Tervo (2013) in their analysis work with panel data, or the data that has two dimensions: time-series and cross-sectional. The investigation of causality in the panel framework is quite more complicated than usual time-series. In our study, in order to detect the causality in panel data, we will use the procedure proposed by Dumitrescu and Hurlin (2012) for testing Granger-causality in panel datasets.

The underlying regression, in this case, writes as follows:

$$y_{it} = a_i + \sum_{p=1}^{P} \gamma_i^{(p)} y_{i,t-p} + \sum_{p=1}^{p} \beta_i^{(p)} x_{i,t-p} + \varepsilon_{i,t} \qquad (1)$$

Where y_{it} – a measurement of regional development (GRP per capita) for the region *i* in time *t*; $x_{i,t-p}$– measurement of airport activity (number of passengers traffic per month (2010-2019) for the region *i* in time *t*, and *p* is the number of lags. The coefficients could be different across the regions but are assumed to be time-invariant. The lag order *P* is assumed to be identical for each *i* and the panel must be balanced.

The approach of detecting causality is the same as in Granger (1969) – testing the null hypothesis that past values of *x* have a significant effect on the present value of *y*. So, the null hypothesis is therefore defined as follows:

$$H_0 : \ \gamma_{i,1} = \cdots = \gamma_{i,p} = 0 \qquad \forall\, i = 1, \ldots, N \qquad (2)$$

Which indicates the absence of causality for all regions in the panel. The alternative hypothesis therefore states:

$$H_1: \ \gamma_{i,1} = \cdots = \gamma_{i,p} = 0 \qquad \forall\, i = 1, \dots, N_1$$
$$\gamma_{i,1} \neq 0 \ or \ \dots \ or\ \gamma_{i,p} \neq 0 \qquad \forall\, i = N_1 + 1, \dots, N \quad (3)$$

Notice that test assumes that causality can be identified for some regions and not necessarily for all. If $N_1 = 0$ then the causality is identified for all regions in the panel. N_1 must be strictly less than N, in another case, there will be no causality between variables.

The procedure of applying the Dumitrscu and Hurlin (2012) approach has several steps: first run the N individual regressions, then perform the F-test of the *P* linear hypothesis $\gamma_{i,1} = \cdots = \gamma_{i,p} = 0$ to obtain the Wald statistics for each region *i* and finally compute the average Wald statistics across N regions.

After this procedure the Z-statistic is calculated. If it is larger than corresponding critical value, than we can reject the null hypothesis and conclude that the causal relationships exist.

3.2 Fixed effect 2SLS analysis

The regression analysis was undertaken in order to examine the relationship between air-traffic and economic growth in Ukraine. The analysis was conducted relating GDP per capita to air-traffic and other variables that might be expected to have an impact on economic growth. It allows to isolate the relationship between economic growth and air-traffic and quantify it while controlling for other factors that may have an impact.

Two main problem that we have to face during this analysis is the possible reverse causality and, as a consequence, the endogeneity of the main explanatory variable – air-traffic volumes. In order to overcome such issue, the two stage least square (2SLS) method were implemented in order to eliminate this problem. The method is similar to that used in Lakew and Bilotkach (2015), Ozcan (2012) and Baltaci and Akbulut (2015), which all based on the study of Brueckner (2003). The main idea of the approach is to replace potentially endogenous variable with the set of instrumental variables that have highly explanatory power in determining the variation of the endogenous variable. Due to the fact that data we used is panel, the fixed effect specification was applied in order to deal with possible heterogeneity of explanatory variable. The reason to use fixed effect specification instead of random is based on the intuitive assumption that the region-specific effects are very unlikely be uncorrelated with other regressors and also justified by the results of Hausmann test.

Finally, the fixed effect 2SLS model is as follows:

First stage:

$$y_{it2} = \Pi_2 z_{it} + v_{it2} \tag{4}$$

Second stage:

$$y_{it} = \delta_1 z_{it1} + \alpha_k y_{it2} + \widehat{v_{it2}} \rho_1 + u_{it} \tag{5}$$

Where y_{it} – is the measurement of economic development of region *i* in time *t*,

$\widehat{v_{it2}}$ – residuals from the first stage regression,

z_{it} – vector of independent exogenous and instrumental variables, where $z_{it1} \subset z_{it}$,

y_{it2} – independent endogenous variable.

The main explanatory variable in our analysis is the volume of air passengers which was log-transformed to facilitate the interpretation process and to reduce the influence of outliers. Air-traffic variable is consisted with the departing and arriving passengers amount (External + Domestic).

The dependent variable (GDP per capita) are measured in USD and adjusted for inflation rate. Log-transformed also as well as in the model by Baltaci and Akbulut (2015). The relationship between two variables are depicted on Figure 3. As it can be seen they are positively correlated which is indicated by upward sloping trend line.

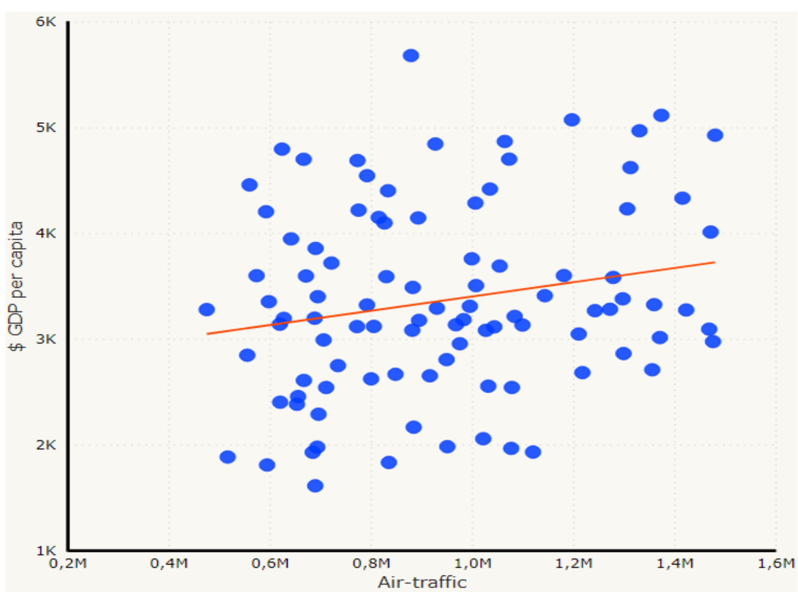

Figure 3. Air-traffic, 2010-2018 vs GDP per capita, 2010-2018

Other factors are regarded as control variables in order to evaluate the relationship between air-traffic development and economic growth. The control variables are represented by following factors: social controls are added to the model as a total population of the region, the number of students of higher educational institutions and the number of unemployed as a percentage of total labor force; economic control represented by the amount of capital investments. The capital investments have potentially large effects on economic growth. Investment in machinery and equipment are a strategic factor of growth and brings a lot of benefits in generating further technological process (Gould and Ruffin, 1993).

Potential co-determination issue between region population and GDP per capita are avoided by lagging population variable by one year. Therefore, while the whole sample begins 2010.01, measures for population begin as early as 2009.01, similar to Lakew and Bilotkach (2015).

Also, we use dummy variables to control for some positive and negative shocks that may have impact on economic growth. One of dummy variable is named ATO and it captures the hottest phase of war in Donbas, in particular, since April 2014 till the end of 2015. Also the free trade dummy was added to the analysis. It captures the period since September 2017 when the Assosiation Agreement which includes the Deep and Comprehensive Free Trade Area between Ukraine and EU entered fully into force[3].

Due to fact that relationship between the GDP per capita and air-traffic is contemporaneous one (they are determined simultaneously) and it's unclear how much the observed traffic is a consequence of the corresponding region's GDP the set of instruments were applied for addressing this problem. The instruments were chosen in order to fulfill the following criteria: strong correlation with air-traffic volumes and weak (or no) correlation with error terms in Equation (5). In

[3] https://www.kmu.gov.ua/en/yevropejska-integraciya/ugoda-pro-asociacyu

practice we can test the first requirement but cannot test the second one because *u* is unobserved, so we rely on economic theory to find instrumental variables that satisfy the second requirement. The first requirement was tested by obyaining F-statistic of the first stage regression (see Appendix D). We used three instruments namely proximity, seasonality, and capacity. The choice of these instruments mainly based on the works of Lakew and Bilotkach (2017) and Ozcan (2012). The proximity is the variable that measure the distance in the kilometers to the closest operating airports. The use of it is rather more unquestionable, due to fact that proximity to the nearest airport will naturally affect its air-traffic and it's very unlikely that the proximity of the airport is correlated with error terms in Equation (5).

The seasonality is one of the main determinants of air-traffic, especially for the small regional airports, which generate most of their traffic during the high-season period, which, as we can observe on Figure 4, for almost all airports falls for the time since April till October. Consequently, the variable is equal to 1 for these months, and 0 otherwise.

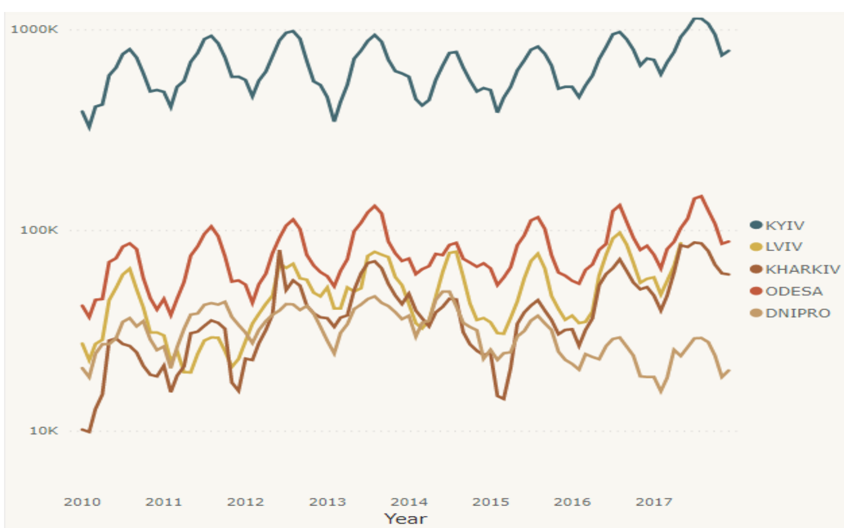

Figure 4. The seasonality of air-traffic

High capacity instrumental variable equals 0 in case that passenger amount is less than 1 million for 1 year and 1 otherwise. The seasonality fluctuations were taken into account in specifying this variable, so for high-season months the threshold is equal to 105 000 passengers per month and for low-season months – 60 000. Despite that capacity is one of the main drivers of traffic, the exclusion requirement and non-correlation with the error term is less obvious due to fact that larger airports are more likely to be located in larger metropolitan areas which are, in general, much more developed than other regions, so it follows that capacity and economic development can be correlated. However, the main determinant of suitable instrument is that unobserved sources of variation in GDP per capita are not correlated with the instrument (capacity). Therefore, since we control for the population size of the region in our specifications we can assume that remaining variation in the error term has negligible relationship to the airport capacity.

To enable interpretation of our coefficient estimates as elasticities the population, unemployment, human capital and capital investment are included into all specifications in logarithmic form.

Thus, the second stage model specification is as follows:

$$
\begin{aligned}
lnGDP\ per\ capita_{it} &= \beta_1 \ln AirTraffic_{it} + \beta_2 \ln Population_{it} \\
&+ \beta_3 \ln Education_{it} + \ln CapInvestment_{it} \\
&+ \ln Unemployment_{it} + ATO + FreeTrade + a_i + u_{it} \quad (6)
\end{aligned}
$$

In the equation above: α_i – region i fixed effect, i – region, u_{it} – error term.

The estimations are performed using STATA 14.0. A p-value of 0.05 was taken as the statistically significance level.

Chapter 4

DATA OVERVIEW

4.1 Data sources

The most of data was collected from the State statistical service (SSS) of Ukraine and its regional branches websites. On them we found the data for the independent variable – GDP per capita, and for the controlling variables that were used in regression analysis such as human capital, population, level of unemployment and the size of capital investments. All that data was collected for the particular sample of regions, that ones that have or had the fully functioning airports. That sample consists of such regions as: Kyiv city, regions of Odesa, Lviv, Kharkiv, Dnipro, Zaporizhzhia, Donetsk (till 2014), Simferopol (till 2014), Kherson (since 2015), Ivano-Frankivsk (since 2012) and Chernivtsi (since 2017).

The collecting of the data for the main independent variable – the volume of air passengers, was the hardest step in this research. The main problem that arose was the absence of the data on the official sources such as SSS, Ministry of Infrastructure and State aviation service (SAS) or its presence only for last one-two years. Therefore, the data was collected manually from different sources. For the large airports such as Kyiv, Odesa, Lviv, Kharkiv. Dnipro, Donetsk and Simferopol the data was taken from the Eurocontrol database. Eurocontrol or the European organization for the safety of Air Navigation is an international organization working to achieve safe and seamless air traffic management across Europe. They gather and share a wide range of data – statistics and forecasts, for all their member states[4]. Ukraine is the member of

[4] https://www.eurocontrol.int/

Eurocontrol since 2004, so this is unable us to obtain the data for the largest Ukrainian airports from this database.

For the small airports such as Kherson, Ivano-Frankivs and Chernivtsi, which are resumed their activity recently, the data was collected from the Avianews website database. Avianews is the largest Aviation Industry News website of Ukraine which is operating since 2004 and publishing the data for the air-traffic both for the whole Ukraine and for each particular airport separately with monthly frequency. The data is obtained directly from the SAS or from the airport's authorities[5].

Other data sources were also used. The data on the exchange rate for last 10 years and on PPI and CPI were uploaded from the official webpage of National Bank of Ukraine.

The dummy variables included into analysis are structured as follows: ATO (1 – if the period is since April 2014 to December 2015, 0 – all other dates); Free trade (1 – if the period since September 2017, 0 – all that is prior this date). We decided not to include the dummy that captures any region-specific features, such as institutions, because all investigated regions are located in the same country, and as a result in the common institutional framework, this commonality reduces the varying impact on growth resulting from institutional differences (Martinez-Galarraga, 2015).

4.2 Data description

Data set before cleaning include 1176 observations. The main explanatory variable – *air traffic*, has 397 missing values, which is explained that some airports don't have traffic at all prior to some date, and some stop its activity after some date (Donetsk and Simferopol). The dependent variable – *GDP per capita*, has 47 missing observations and after log-transforming the number of missing observations has increased to 168

[5] https://www.avianews.com/ukraine/

and the final sample includes 612 observations due to strongly balance panel requirement. So, the problem of missing data is quite serious.

In order to deal with possible estimation bias and, in particular, to assess the difference in impact of air activity on economic development, the whole sample was divided into two subsamples. The large airports such as Kyiv, Odesa, Lviv and Dnipro were grouped separately from the small airports such as Kherson, Ivano-Frankivsk, Zaporizhzia and Chernivtsi. Donetsk and Simferopol airports were excluded from the regression analysis due to absence of majority of economic and social data since 2014.

Variables of the main sample and the descriptive statistics are shown in the Table 1 below. All the variables are log-transformed with sake of easier interpretation. Worth noting the great dispersion in Air-traffic relatively to other variables which can be explained by high differentiating in economic activity between the regions.

Table 1. Descriptive statistics

Variable	Mean	SD	Min	Max	N
Log of GDP per Capita	7.99	0.58	6.61	9.73	1020
Log of Air-traffic volume	10.47	1.72	2.63	13.95	791
Log of Population	14.55	0.48	13.71	15.31	1079
Log of Unemployment	9.58	0.53	8.29	10.57	944
Log of Human Capital	11.42	0.93	9.91	13.24	864
Log of Capital Investments	11.21	1.07	8.44	13.9	972
Dummy on Free Trade with EU	0.22	0.42	0	1	1176
Dummy on ATO	0.19	0.39	0	1	1176

In Table 2 we have provided the comparative statistics of sample of large and small regions. Concerning the relationship between economic development and airports activity we observe that the large airports are likely to be located in the most development areas. Specifically, without taking into account the volumes of air-traffic the GDP per capita of large regions is more than twice higher than analogous value for small subsample – 4595 USD against 2193 USD.

Table 2. Comparative statistics of large and small regions subsamples

Variable	Mean of large subsample	Mean of small subsample
GDP per Capita	4594.7	2193.4
Air-traffic volume	181260.8	9758.2
Population	2759973	1280724
Unemployment	20131	12354.6
Education level	192591	40103.7
Capital Investments	200089.3	44473.4

To some extent such difference in economic development could be explained by the other factors. Consistent with the literature the higher level of capital investment and overall human capital, which is represented by the number of University students, leads to increasing in labor productivity and to boosting operational efficiency of the companies which consequently leads to higher level of economic growth.

Chapter 5

RESULTS

5.1. Causality test results

Our core empirical findings, using three samples of the regions for bivariate case, apply three lag order for the whole sample, the same lag order for the largest region and two lag order for the sample of small regions. The determination of the lag order is based on the results of various lag selection criteria such as the Aikaike's information criterion (AIC), Schwarz information criterion, Hannan-Quinn criterion (HQC), final prediction error (FPE) and Bayesian information criterion (BIC). The estimation was conducted for each region separately and lag order was determined as the most frequent lag in each sample. For the sample of large regions, the most frequent lag was third, while for small ones – second. For the whole sample was chosen the lag of three as the average of the lags for two subsamples. AIC and FPE estimation results were taken as a superior to other results due to their better performance in the case of small sample size (less than 120 observations), and which found to produce the least probability of under estimation among all criteria under study (Liew, 2004). However, the problem of overestimation is negligible in all cases and all criteria showed mostly the same lag order for each region. The final table of lags for each region under different estimation criteria is provided in Appendix A. Also it should be noted that the variation of lags from 2 to 4 has no effect on the final conclusion based on estimation result of causality.

The results are given in Tables 3 and 4. The intuitive hypothesis that is tested using this approach is that causality is present and it has two-way nature, which means that the air-traffic expanding has the impact on economic development which in turn also has its own impact on the volume of air-traffic. The second hypothesis that is tested is the heterogeneity in the causality results for different samples. It assumed that for core and remote regions the result could be different, and that the volumes of air-traffic that remote regions have could be not enough to generate the regional catalytic effect

Table 3 provides results of the assessment of the homogeneous non-causality hypothesis (HNC) for the passenger volume as an independent variable (that causes) and GDP per capita as a dependent variable (which is caused). The HNC hypothesis implies the non-existence of individual causality relationship.

Table 3. The Granger non-causality test results: PAX → GDP per capita

	Whole sample	Large regions	Small regions
W-bar	9.109	11.297	4.588
Z-bar	7.887	7.574	2.588
P-value	0.000	0.000	0.009

The test statistics of the homogeneous non-causality hypothesis are statistically significant with third lag for the whole sample and with fourth and second lag for the subsample of large and small regions respectively when the direction of causality is from air traffic to regional development. For all three tests the p-value is extremely small and Wald and Z-statistics are quite large, so we can reject the null hypothesis and conclude that air-traffic does Granger-cause GDP per capita in all three cases.

The next step is to determine whether the causality is two-way for the samples. The results are provided in Table 4.

Table 4. The Granger non-causality test results: GDP per capita → PAX

	Whole sample	Large regions	Small regions
W-bar	6.244	11.226	1.25
Z-bar	4.188	7.509	-0.749
P-value	0.000	0.000	0.456

The causality in direction from GDP per capita to air-traffic is present for first two investigated samples – the whole sample and the large regions. The p-value in all cases are extremely low and the Wald and Z-statistics are sufficiently large, consequently we reject the null hypothesis in these cases. While for the small regions the result is a bit surprising. The p-value is quite high and it remains high despite the lag-order we choose (from 2 to 4), so we cannot reject the null hypothesis about absence of causality for small regions and conclude that the level of GDP per capita doesn't Granger-cause the air-traffic in these regions.

The results of these tests indicate that the two-way causality is present for the whole sample and for the subsample of large regions, while for the small regions subsample the causality is present only in the direction from air-traffic to GDP per capita. Worth noting that the expanding economic activity is one of the crucial components of economic development in that areas, but this activity of itself could be not enough to generate the impact on its region's development, which is consistent with the Breidenbach (2019) conclusion. In order to check this assumption, the analysis that quantify the impact of air-traffic on GDP per capita was conducted.

5.2. Regression analysis results

The first step in this process was to choose the appropriate model specification taking into account the endogenity of the main explanatory variable – air-traffic. 2SLS Fixed effect model specification were applied in this case with using the set of instrumental variables. The Fixed effect approach was chosen based on Haussmann test (Appendix B).

Tables 5 to 7 provide the results for the second stage estimation of (6) with two specifications: in first one we estimate the model without dummies for *ATO* and *Free Trade* in order to emphasize on the magnitude of these macroeconomic shocks, especially for the former one; and in the second model we add these variables and control for such shocks. Consequently, the last column in each table represents the main results of estimation based on which we made our conclusion. For comparison the same equations are estimated using usual Fixed effect approach, without applying IV method and these results included in the same table. The coefficients on the airport traffic and economic and social control variables are displayed, along with the R-squared and the standard errors we report are robust to heteroscedasticity and autocorrelation within regions. The results for the first stage regression are displayed in the Appendix C. The instruments were tested on validity by obtaining F-statistic from first stage regression. The result of F-test is provided in Appendix D. Rule of thumb of determining weak instruments states that F-statistics of instrumental variables should be larger than 10 to ensure that the maximum bias in IV estimators to be less than 10% and 5 to ensure that bias is less than 20% (Staiger and Stock, 1997), so based on the test result selected variables are indeed valid instruments for all sample specification. The largest F-statistic is observed for the largest regions – 96.39, and the smallest for the small subsample – 6.44.

Table 5 gives the estimation results for the whole sample which support our hypothesis about positive impact of air-transportation on economic development.

Table 5. Estimation results for the whole sample

Variable/Model	Log (GDP per capita)			
	(FE)	(FE-2SLS)	(FE)	(FE-2SLS)
Intercept	-26.060	-23.993	-26.838	-38.837*
	(21.373)	(19.232)	(14.413)	(21.974)
Log (PAX)	0.018	0.010	-0.002	0.048**
	(0.028)	(0.026)	(0.026)	(0.019)
Log of Population	1.841	1.715	1.882	2.646*
	(1.488)	(1.363)	(1.051)	(1.540)
Log of Human Capital	0.444**	0.432***	0.390**	0.434***
	(0.137)	(0.135)	(0.121)	(0.139)
Log of Unemployment	-0.124*	-0.125*	0.039	0.035
	(0.065)	(0.064)	(0.063)	(0.071)
Log of Capital Investments	0.265***	0.267***	0.216***	0.203***
	(0.028)	(0.026)	(0.024)	(0.023)
Dummy on Free Trade with EU			0.071**	0.053**
			(0.028)	(0.027)
Dummy on ATO			-0.317***	-0.316***
			(0.012)	(0.01)
N	612	612	612	612
R^2	0.5625	0.5693	0.5457	0.5162

Notes: Robust standard errors in parentheses * if p-value < 0.1, ** if p-value < 0.05, *** if p-value < 0.01

Based on the result of the main specification, which are given in Table 5, we can interpret the coefficients as follows: holding all other variables fixed in the model on average 10% increase in volume of air-traffic leads to 0.48% increase in GDP per capita. This result is highly statistical significant (p-value < 0.000) and it worth noting that it's significant only in case of accounting for all control variables including the variables for macroeconomic shocks such as ATO and free trade launch. The controlling variables are also to be found to have strong significance and to show logical sign. Exceptions are the variables for population and unemployment which are insignificant in all four specifications. At the same time the controls for human capital and capital investment together with included dummies demonstrate statistically significant and quite similar coefficients in all specifications with logical signs, which could mean that these control variables are truly exogenous and don't vary much in response of changing the model specification.

Overall, our main model with fixed effect together with applying the IV methodology and including the dummies can explain about 52% of the variation in GDP per capita for the whole investigated sample.

Table 6 presents the estimation results of the sample of large regions. As for the main sample we find that relationship between air-traffic and GDP per capita is positive and statistically significant in all model specifications, except the FE-2SLS without dummy variables. The coefficient is statistically significant in both case, whether we use instruments or not, but in the latter case the effect is much higher. It's almost five times higher than the coefficient of 2SLS regression and more than three times higher for the analogous coefficient in previous regression.

Based on the results of the main model we can make following interpretation: 10% in the traffic of the largest Ukrainian airports, on average, leads to 0.33% increasing in GDP per capita of corresponding regions. Worth noting that control variables such as population and level of unemployment again have insignificant coefficients in all specifications, while the controls for human capital, investments and macroeconomic shocks demonstrate highly significant and very similar coefficients in all models. Overall, the main model explains almost 87% in variation of GDP per capita of included regions.

Table 6. Estimation results for sample of large regions

Variable/Model	Log (GDP per capita)			
	(FE)	(FE-2SLS)	(FE)	(FE-2SLS)
Intercept	-14.335	-36.655	0.558	-13.982
	(32.931)	(23.373)	(17.209)	(19.864)
Log (PAX)	0.186**	0.020	0.152**	0.033*
	(0.061)	(0.048)	(0.041)	(0.018)
Log of Population	0.662	2.485	-0.225	0.962
	(2.391)	(1.743)	(1.162)	(1.383)
Log of Human Capital	0.615**	0.461***	0.439***	0.346**
	(0.154)	(0.125)	(0.089)	(0.136)
Log of Unemployment	0.036	-0.085	0.163***	0.086
	(0.121)	(0.105)	(0.033)	(0.056)
Log of Capital Investments	0.246***	0.264***	0.211***	0.224***
	(0.036)	(0.031)	(0.022)	(0.025)
Dummy on Free Trade with EU			0.033**	0.045***
			(0.016)	(0.016)
Dummy on ATO			-0.317***	-0.322***
			(0.015)	(0.014)
N	469	469	469	469
R^2	0.8119	0.8290	0.8219	0.8692

Notes: Robust standard errors in parentheses * if p-value < 0.1, ** if p-value < 0.05, *** if p-value < 0.01

Table 7 provides the regression outputs for the sample of small regions. The obtained results support the conclusions made based on the previous analysis and also support the initial hypothesis about heterogeneous effect of core and remote regions on economic development. The coefficient on air-traffic in the main model is 0.028, which is similar to the previous result obtained for the whole and large regions sample, but p-value is relatively quite high (0.214), which mean that we failed to reject our null hypothesis about the absence of relationship between these two variables under all confidence intervals that we used in our research (90% and 95%). The insignificant coefficients on air passenger's volume means that regional airports in these regions more likely have no impact on economic development. The result again is quite unexpected, taking into account the results of causality tests. There could be two reasons for such outcome: the first one is the small sample size of observations due to fact that 3 out of 4 airports including in this sample resumed their activity in the last 10 years, and for the largest airport of the sample – Zaporizhzhia, despite that this airport didn't stop its activity, the data contains a lot of missing values, in particular for years of 2010, 2011 and 2014. The second reason is that the volumes which are operated in these airports are not enough to generate the catalytic impact on the regional economy.

The control variables in the main model demonstrates the same patterns as in two previous ones. The insignificant coefficients for population and unemployment, and highly significant for human capital, investment and macroeconomic shocks. The coefficients exhibit approximately the same magnitude of the impacts and logical signs in all specifications. According to the main model, almost 80% of variation of GDP per capita in these regions are explained by these variables.

Table 7. Estimation results for sample of small regions

Variable/Model	Log (GDP per capita)			
	(FE)	(FE-2SLS)	(FE)	(FE-2SLS)
Intercept	168.138*	158.14***	66.991*	-46.176
	(52.216)	(39.051)	(22.05)	(49.689)
Log (PAX)	-0.040***	-0.029	-0.030	0.028
	(0.003)	(0.033)	(0.011)	(0.021)
Log of Population	-12.424*	-11.74***	-4.923	3.112
	(4.197)	(3.247)	(1.784)	(3.674)
Log of Human Capital	1.577*	1.597**	0.997*	0.875***
	(0.536)	(0.628)	(0.283)	(0.321)
Log of Unemployment	-0.319	-0.318**	-0.145**	-0.076
	(0.133)	(0.142)	(0.024)	(0.078)
Log of Capital Investments	0.146***	0.144***	0.126**	0.124***
	(0.006)	(0.007)	(0.017)	(0.022)
Dummy on Free Trade with EU			0.050*	0.144***
			(0.014)	(0.035)
Dummy on ATO			-0.280***	-0.306***
			(0.019)	(0.015)
N	143	143	143	143
R^2	0.6563	0.6522	0.4947	0.7929

Notes: Robust standard errors in parentheses * if p-value < 0.1, ** if p-value < 0.05, *** if p-value < 0.01

Therefore, based on the estimation results of three samples we can conclude that the air-traffic has the impact on economic activity, but the value of this impact is positively connected with the volume of such traffic: the higher the number of air-passengers the higher will be catalytic effect on the regional economic development. It seems to be that airports indeed need to exceed some threshold to generate the regional spillover (Breidenbach, 2019)

Chapter 6

CONCLUSIONS

This paper is the first attempt to analyze the relationship between the airport activity and the regional economic development in Ukraine. The analysis was conducted in two steps. Firstly, we determined whether these two variables have any relationship at all using Granger causality framework, and secondly we quantify the effect of air-traffic on GDP per capita by applying instrumental variable approach in fixed effect specification in order to deal with endogeneity of air-traffic measure. The causality test and the regression analysis were conducted on the panel data of GDP per capita and Air passenger volumes of all constantly operating airports that span the period of 2010-2018. The set of control variables for economic and social factors of the regions were also added to the regression. Earlier studies that investigate similar relationships in other countries clearly indicate that high level of air-traffic has positive and significant effect on regional economy. Our findings in most cases are consistent with these studies and support the idea that the well-developed transport infrastructure is indeed a facilitator that encourages the economic potential of a region to be realized (Mukkala and Tervo, 2013).

The Granger non-causality method in panel framework allowed us to investigate causal relationship between GDP per capita and air-traffic and determine in which way this causality goes. The test showed that causality has two-way nature in case of the whole investigated sample and for the largest airports in the country, while the sample that includes small regional airports, which were not operated during long time and resumed its activity in the last ten years, showed one-way causality in the direction from air-traffic to GDP. Thus, in this region the air activity appears to boost regional development, but not vice versa, which is quite surprising result that means that the revival of these airports is more unlikely connected with economic development of these regions and apparently caused by some other factors, such as political (one of the reason of revival of Kherson airport in 2015 was not so connected with economic component as dictated by the need to an airport in this region after Crimea annexation by Russia).

The positive effect of air-traffic was confirmed in the following regression analysis. In particular, a 10% increase in the air-traffic leads to, on average, a 0.47% increase in regional GDP per capita for all investigated regions, and 0.33% for the largest one. At the same time, the result for the sample of relatively small regions indicate no effect of air-traffic on GDP per capita, which is in some way goes against our causality test's results. But, there are a couple of possible explanation for such outcome. First one is limited number of observations which makes us fail to document the econometric relationship between our variables of interest. For some airports the data is limited due to fact that they resumed their work only in last 5-10 years, and consequently their traffic history is quite short, and for other airports the data is simply missing for some periods and we were not able to find it in the open sources. The other possible explanation is based on the assumption proposed by Breidenbach (2019), that the simple airport activity is not enough to make an impact on the economy, and that the airport has to exceed some threshold in the volume of its traffic in order to produce some spillover effect for the regional development. Taking into account that average air-traffic of the airports investigated by Breidenbach is approximately 400 thousand passengers per year[6] which is much higher than the traffic of such airports as Kherson, Chernivtsi and Ivano-Frankivsk, included in the sample, this assumption looks quite reasonable.

In general, the relationship between the volumes of air-traffic and the magnitude of its effect on economic development is crucial for determining appropriate

[6] https://www.adv.aero/wp-content/uploads/2018/03/12.2017-ADV-Monatsstatistik.pdf

policy implications aimed at developing airports infrastructure. In particular, this is important amid Government plans to restore all 50 airports in Ukraine till 2030 (Ukraine. Ministry of Infrastructure, Air-transport 2018). Such ambitious goal requires a lot amount of investments, because almost all regional airports are suffering of significant deterioration of all infrastructure elements. Therefore, question of relevance and especially of opportunity cost of such investment is arising in this case. Because if the airports are generating spillover effect only in case when they reach some substantial amount of traffic, such government investments could not be effective due to reason that they might create excess supply of air-traffic slots in some areas that may make particular airports less necessary and consequently limit their effect on the local economy. Moreover, the dispersion of the passengers among these airports can make majority of them unprofitable due to low amount of traffic that will be served in each airport which in turn entail additional costs from the government in the form of subsidies to support these airports and prevent their closure.

Therefore, in order to avoid such waste of money, the Government should adopt the policy which will be aimed at supporting already operating airports and at increasing the amount of their traffic. The decision of opening new airports should be made only after careful analysis that this airport catches the area where it may indeed generate a significant passengers traffic and to be profitable in its activity.

In that circumstances the Government could kill two birds with one stone: save the additional funds on the amount of airport investments and subsidies and to create added value to regional economic development.

The decision of opening a new airport and determining factors that affect such a decision is the question of future studies. In this context, the results of this research could be used as one of the justify arguments in favor of building the airport. Also, it’s important to test the accuracy of the obtained results with more data available in the future, especially for the small airports. The absence of the most recent data was the main reason why such airports of the cities as Vinnytsia, Mykolaiv, and Poltava were not included in analysis. The question that deserves special attention is the investigation of the effect of another important component of air-traffic – cargo transportation. At the time of writing this research, such a question has become incredibly relevant against the background of the Covid-19 epidemic which caused irreparable damage to the entire airline industry and forced a lot of airlines to almost completely stop PAX transportation and retrained their own planes for cargo transportations. Many airlines have already announced such intentions both abroad[7] and in Ukraine[8]. Also, it's important to investigate how the airport activity, both PAX and cargo transportation, affect not the economy overall but the different macroeconomic indicators such as employment and production in different sectors and regions as well as volumes of export and import. These studies are very important in designing the most appropriate policy implications and conducting comprehensive welfare analysis, but their research directly depends on the availability of suitable data, limitation of which is still a very important problem and obstacle in conducting such studies for Ukraine.

[7] https://www.aircargonews.net/airlines/lufthansa-strips-out-seats-to-create-extra-cargo-space/
[8] https://skyup.aero/en/news/vantazhni-perevezennya-skyup-airlines-rozvivaye-novij-napryam-diyalnosti_177

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APPENDIX A

Table 8. Optimal lag order for each selection criteria results

Region/Selection criteria	FPE	AIC	HQIC	SBIC
Kyiv	3	3	3	3
Odesa	3	3	3	2
Lviv	2	2	2	2
Kharkiv	4	4	2	2
Dnipro	3	3	3	3
Donetsk	4	4	4	2
Simferopol	2	2	2	2
Ivano-Frankivsk	2	2	1	1
Kherson	2	2	1	1
Zaporizhzhia	3	3	3	2
Chernivtsi	2	2	2	2

APPENDIX B

HAUSSMANN TEST

Table 9. The result of Haussmann test

	Coefficients			
	(b) Random	(B) Fixed	(b-B) Difference	S.E.
Log (Passenger's traffic)	0.08	0.05	0.03	0.02
Log (Population)	-0.87	2.65	-3.52	
Log (Human Capital)	0.30	0.43	0.14	
Log (Capital Investment)	0.42	0.20	0.21	0.02
Log (Unemployment)	0.20	0.04	0.16	0.04
ATO	-0.29	-0.32	0.02	0.03
Free Trade	0.04	0.05	0.01	0.02

b – consistent under H_o and H_a

B – inconsistent under H_a, efficient under H_o

Test: H_o: difference in coefficients not systematic

chi2 **(7)** = (b-B)'[(V_b – V_B)^(-1)](b-B) = **162.06**

Prob > chi2 = **0.0000**

(V_b – V_B is not positive definite)

APPENDIX C

Table 10. First stage results

Variable/Model	Log (PAX)		
	(Whole sample)	(Large regions)	(Small Regions)
Intercept	249.25 (264.74)	-117.96 (88.55)	1723.321** (263.63)
Log of Population	-15.866 (17.985)	9.576 (6.104)	-122.61** (18.346)
Log of Human Capital	-0.988 (1.123)	-0.736* (0.321)	1.408* (0.377)
Log of Unemployment	0.215 (0.592)	-0.510 (0.273)	-0.407 (0.874)
Log of Capital Investments	0.268** (0.107)	0.079 (0.059)	0.296 (0.130)
Dummy on Free Trade with EU	0.376 (0.225)	0.019 (0.107)	-1.262 (0.496)
Dummy on ATO	-0.073 (0.103)	-0.078 (0.097)	0.331 (0.617)
Seasonality	0.420*** (0.055)	0.355*** (0.029)	0.527** (0.084)
Capacity	0.312* (0.149)	0.382** (0.125)	Omitted
Proximity	0.000 (0.000)	-0.000 (0.000)	-0.001* (0.000)
N	612	469	143
R^2	0.3633	0.0030	0.0315

APPENDIX D

Table 11. The result of F-test

Null Hypothesis	Whole sample		Large regions		Small regions	
	F-statistic	Prob>F	F-statistic	Prob>F	F-statistic	Prob>F
Capacity = 0 Proximity = 0 Seasonality = 0	21.03	0.000	96.39	0.000	6.44	0.000