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MODELING THE IMPACT OF AIR TRANSPORT ON THE ECONOMY - PRACTICES, PROBLEMS AND PROSPECTS

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ABSTRACT. **Background:** The issue of measuring the contribution of air transport to the regional economy is very important nowadays since many airport infrastructure projects are being implemented, using available European Union funds. As a result of growing transport needs and increasing incomes among the population, the air transport market is strongly developing. This development results to many direct and indirect socio-economic benefits to locations in close proximity of an airport but also in the whole economy. The measurement of these benefits is important because the decisions made with respect to air transport influence local and regional economic performance. The most commonly used tool for measuring the positive effects associated with the operation of an airport is the input-output analysis. The aim of the article is to present the characteristics of the input-output method, to indicate its applications in Poland - the country with the most dynamic growth of air transport, to present the possible limitations of this method and propose improvements.
Methods: The method used in this research is one that measures the effects of changes in the economy as a result of air transport activity. Particular input-output analysis is used.
Results: On the background of the results of modeling the impact of polish airport on regional economy in 2009 the updated analysis in 2012 is provided. The economic impacts of Krakow, Katowice, Wroclaw and Szczecin airports are estimated. Then the limitations of input-output method are presented and suggestions of possible improvements are made.
Comments: Proper measurement of the impact of airport's operation and investment on the economy, leads to more effective air transport policy development. For future research, the advanced input-output method to assess the positive impact of airports on regional development is recommended. However, a comprehensive assessment of the operation and expansion of airport infrastructure requires comparing the economic benefits with economic costs.

Key words: airport, regional development, input-output analysis.

INTRODUCTION

In Central and Eastern Europe, where the aviation market has been deregulated and new companies entered the market, the air transport market is developing very dynamically. The growing air traffic caused capacity problems and lead to new investments in airports' infrastructure. The expansion of airports was enhanced by the UEFA Championships requirements in terms of airports infrastructure endowment in Poland - the largest of CEE countries. Moreover the local governments intend to benefit from air transport market development and start to build new airports from scratch or rebuild existing military airfields in order to transform them into civil airports, often with financial aid from EU funds. As a result, airport infrastructure in Poland has been changing dynamically and almost all airports in Poland are benefiting from infrastructural investments.

In 2012 new airports entered the polish market namely Lublin and Modlin and two

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additional airports (Gdynia and Szczytno) are being prepared to be operational in the nearest future. However one can observe that not all investment projects are economically viable or contribute to increase the social welfare in the long run. Airlines are less interested in providing scheduled flights from the newest airport that was opened in 2014 in Radom. Other regional airports (Lodz, Rzeszow, Lublin) are at risk of returning the EU financial aid, due to failure to achieve the planned number of passengers. Based on these observations, a need to develop a proper tool in order to measure the economic and social effects of airport investment project is clearly highlighted.

This paper is organized as follow: in the next section the state of knowledge concerning the impact of air transport on economy is presented; then the characteristics of the most popular method: input-output model are provided; in the following section the results of the research in the polish market are revealed. The next section includes the critical review of input-output method. In the before last section the improvements in modeling the impact of air transport on economy are suggested. The conclusion and directions for further research are highlighted in the last section.

THE PROBLEM OF THE RELATIONSHIP BETWEEN AIR TRANSPORT AND REGIONAL ECONOMY – STATE OF THE ART

The research on the contribution of air transport infrastructure to the regional economy has the longest history in the United States of America. The reason for this is that the U.S. has the highest number of traffic volume hence a well developed airport network. The U.S. was first to deregulated the air transport market and as a result experienced air traffic growth.

The guidelines for the modeling of the economic significance of an airport was established in the U.S. in the late eighties of the twentieth century by the Federal Aviation Administration. Butler and Kiernan [1986] in their documents: "Measuring the Regional Economic Significance of Airports" and it's updated version "Estimating the regional economic significance of airports" set the framework for measuring the socio-economic impact of an airport in terms of income and employment that can be directly or indirectly attributed to the operation of an airport [Butler and Kiernan 1986].

The methodology had been widespread in Europe. In 1992 the European branch of Airports Association Council International gave the recommendation for conducting airport impact studies with the use of input-output methodology. The study called "Airports partners in vital economies" stated that airports are major economic assets offering major economic returns and benefits. Decisions made in respect of airports are those that affect local and regional economic performance [ACI 2004].

Based on the ACI (Airport Council International) Europe and U.S. experiences many airport impact studies at different spatial level were conducted. Until now, almost all hub airports and numerous of regional airports had conducted airport impact studies. A large number of studies have been carried out in US and Europe but also in Asia, Africa, the Middle East and South America. Airport impact studies have spread among the world mainly due to their relative simplicity of application and relative low cost of conducting analysis.

A positive correlation is observed between the need of justification of airport expansion and number of airport impact studies. Particularly, the number of airport impact studies coincides with the time of market liberalization - this is because the growing traffic requires infrastructure improvement which leads to airport expansion and may cause disagreement of local community or environmentalists.

INPUT-OUTPUT MODEL AS A TOOL IN THE MEASUREMENT PROCESS OF ECONOMIC AND SOCIAL EFFECTS OF AIR TRANSPORT

Input-output model is a quantitative economic technique that presents the interdependencies between different branches (particular production sectors) of a regional or national economy. It was developed in the thirties- forties and it is used to measure the amount of factors inputs required to produce a given set of outputs [Leontief 1986]. With the use of this tool one can calculates the response of the economy to the changes caused by the implementation of particular project or the modification of policy.

Fundamentals of input-output method have been created by W. Leontief and they were simplified versions of the classical theory of general equilibrium. The economy is presented as a system of interconnected branches and the flow of goods between them connects all sectors of the economy. On the one hand, this flow presents the successive stages of production, on the other, generated values. Therefore the relationships between the various sectors of the economy can be represented by the matrix:

$$\begin{aligned} &X_{11} + ... + X_{1n} + Y_1 = X_1 \\ &X_{i1} + ... + X_{in} + Y_i = X_i \\ &X_{n1} + ... + X_{nn} + Y_n = X_n \end{aligned} \qquad (1)$$

where the output (or value added) of the branch (i) marked as X_i is the sum of the intermediate production X_{ij} made in the branch (i) and consumed in the industry (j), otherwise known as flow of the final demand Yi of the branch (i) to the branch (j).

Input-output model, which describes the relationship between global product and the end product can be written as a matrix equation:

$$\underline{Y} = (\underline{I} - \underline{A})\,\underline{X} \qquad (2)$$

The equation 2 is called the Leontief model. Assuming (I-A)10 equation 2 can be written as:

$$\underline{X} = (\underline{I} - \underline{A})^{-1}\,\underline{Y} \qquad (3)$$

where the element $(I-A)^{-1}$ is called the Leontief-inverse and informs about how many units the value of production of industry (i) must increase to achieve an increase of one unit of the final product of the branch (j) with the unchanged final products of others branch. This element is called the coefficients of full material consumption. The extra income generated in the production process is partly used to purchase additional goods and services. The increase in the final demand will be higher than the initial increase in income. This effect is sometimes called the induced impact [Hujer and Kokot 2001].

Extended input-output model, in which the changes of the output ΔX caused by the changes in final demand ΔY can be written as follow:

$$\Delta\underline{X} = (\underline{I} - \underline{A})^{-1}\,\Delta\underline{Y} \qquad (4)$$

The changes in final demand ΔY have an impact on changes in revenue across all sectors of the economy. Vector b includes input coefficient for income generated in every sector of the economy, the element $b_j = W_j/X_j$, where W_j is the income split between households (income from work and profits) X_j is the output of branch (j). ΔW_o is the sum of changes in income across all sectors as a result of changes in final demand ΔY.

$$\Delta\,\underline{W_o} = \underline{b}\,(\underline{I} - \underline{A})^{-1}\,\Delta\underline{Y} \qquad (5)$$

Indirect income effects of an infrastructure project can be calculated according to the equation 6.

$$\Delta\,\underline{X_{indir}} = \underline{b}\,(\underline{I} - \underline{A})^{-1}\,\Delta\underline{Y} \qquad (6)$$

While the employment effects are calculated using a sectoral coefficient of labour $(AK_i) = E_i/X_i$ which is the ratio of the number of employees to the gross value.

$$\Delta\,E_{indir} = \underline{AK}\,(\underline{I} - \underline{A})^{-1}\,\Delta\underline{Y} \qquad (7)$$

Induced effects include the revenue created by the spending of employees in entities directly and indirectly related to the airport. The induced impact is a multiplier effect of the sum of direct and indirect impacts. In order to

calculate the induce effect of an airport one should determine the consumption function and incorporate it into the model inputs and outputs. The matrix multiplier consumption is expressed by a reverse matrix $(I-V)^{-1}$. The relationships between direct effects and induced, as well as intermediate and induced are represented in the equation 8 and 9 [Hujer and Kokot 2001]:

$$\Delta \underline{X}^{dir}{}_{ind} = (\underline{I} - \underline{A})^{-1} (\underline{I} - \underline{V})^{-1} \Delta \underline{Y}_{dir} \quad (8)$$

$$\Delta \underline{X}^{indir}{}_{ind} = (\underline{I} - \underline{A})^{-1} [(\underline{I} - \underline{V})^{-1} - I] \Delta \underline{Y}_{indir} \quad (9)$$

Induced effects are calculated using the same interdependencies that occur in indirect effects. The data on the flow of intermediate goods, which are a direct incentive to the creation of an intermediate effect and then induced are used. In order to avoid double counting, in the equation 9, indirect effects were excluded from the induced effects.

The overall effect induced is the sum of the partial results:

$$\Delta \underline{X}_{ind} = \Delta \underline{X}^{dir}{}_{ind} + \Delta \underline{X}^{indir}{}_{ind} \quad (10)$$

According to the input-output method, the total economic impact of air transport is the sum of direct, indirect and induced effects. In some studies input-output effects are calculated differently however their definitions are fairly homogenous.

The input-output model mainly measures income and employment generated by the operation of an airport. Earnings and fiscal effects are expressed in monetary terms and flow in economy being stimulated by the changes in the size and structure of the production. Employment effects result from changes in the physical resources. Technical and technological changes are supposed to be included in the calculation of the effect of employment. The standard input-output analysis does not include the effect of price changes. The results of input-output analysis are expressed in nominal terms and refer to a certain period of time, most often: one basic year.

THE EXAMPLES OF APPLICATION OF INPUT-OUTPUT MODEL – POLAND CASE STUDY

The first airport impact analysis in Poland was conducted in 2005 by the research team from Poznan University of Economics. The study focused on the impact of Poznan Airport on the economy of the city and region. The method was constructed to capture the direct, indirect and induced effects generated by the operation of an airport. Due to differences in market characteristic there was a need to adapt the ACI methodology to polish conditions. The study was repeated at main regional polish airports in Wroclaw, Gdansk, Katowice and then in central airport in Warsaw. Then the analysis was continued and the methodology has been enriched by the experience gained during the previous studies in 2005-2008. The research subjects of the analysis conducted in 2010 were three regional airports located in Poznan, Katowice and Gdansk (Table 1). The criterion for selection of the airport was socio-economic profile of regional economy and the volume of air traffic. The inability to quantify all variables and identify correlation between them obligated to make cautious conclusions. Data has been collected between April and September 2010. Due to the fact that financial data relate to 2009 fiscal year, this period was adopted as a base for estimating the economic effects. Is should be noted that due to the financial crisis in 2009 air transport market experienced a decrease in air traffic. Therefore, the actual size of the economic impact was probably greater than the estimated effects.

After the economic crisis, which peak was in 2009 and in which the largest downfall of air transport movements was recorded, air transport in Poland began to grow and airports infrastructure continued to develop in order to meet the growing air traffic needs, as well as through investments related to the preparation of the country for the organization of UEFA Championship in 2012. Undertaking the airports infrastructure investments meant that employment was raised and the regional income was increased by the companies implementing the infrastructure projects. However, these are demand-side effects, short-term, which will end with the completion of the construction phase [Rietveld and Bruinsma

1998]. The long-term impact is the employment growth in the companies directly associated with the operation of an airport, including the airport operator, ground handling or trade and services companies. At the airport in Wroclaw after the expansion of passenger terminal the direct employment has increased almost by half from 1,044 in 2010 to 1,476 in 2012. [Pancer-Cybulska et al. 2014]. Therefore transport investments are important factor for creating the economic impact [Allroggen and Malina 2014]. Additional factor generating employment is active operation of carriers. Wizzair has established its base in Wroclaw in 2010 and Ryanair in 2012. It is estimated that basing one aircraft LCC airlines at the airport contributes to the creation of approx. 35 work places [Pancer-Cybulska et al. 2014].

Table 1. Direct, indirect and induced economic impact of polish airports in 2009
Tabela 1. Bezpośredni i wspomagany wpływ ekonomiczny polskich lotnisk w 2009

	Direct impact		Indirect impact		Induced impact	
	Employment ΔE_{dir}	Income (M EUR) ΔX_{dir}	Employment ΔE_{indir}	Income (M EUR) ΔX_{indir}	Employment ΔE_{ind}	Income (M EUR) ΔX_{ind}
Poznan	1076	21.1	1070	22.5	59	1.27
Gdansk	1214	25.2	886	18.6	49	1.05
Katowice	1954	37.9	832	17.5	46	0.98

Source: Huderek-Glapska 2012

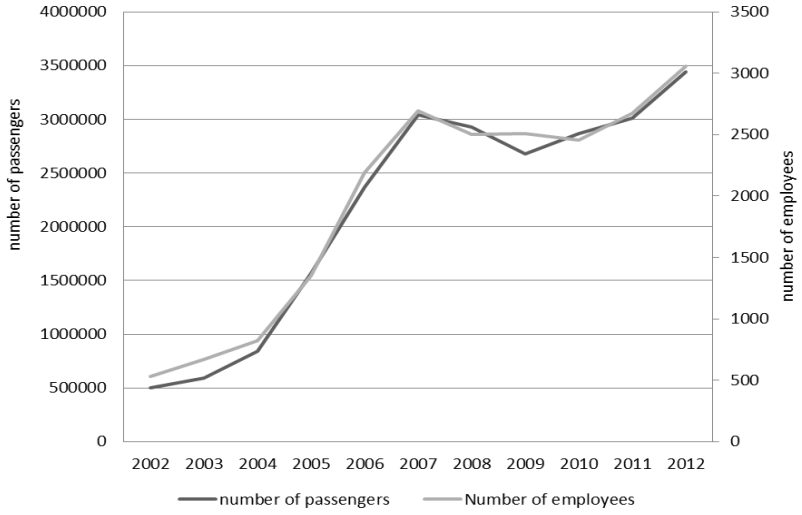
Table 2. Total economic impact and multiplier of polish airports in 2009
Tabela 2. Całkowity wpływ ekonomiczny polskich lotnisk w 2009

	Direct impact			Total impact			Multiplier	
	Employment	Income (M EUR)	Income per passenger (EUR)	Employment	Income (M EUR)	Income per passenger (EUR)	Employment	Income
Poznan	1076	21.1	17	2205	44.9	35.9	1.05	1.13
Gdansk	1214	25.2	13	2149	44.9	23.8	0.77	0.78
Katowice	1954	37.9	16	2832	56.4	24.5	0.45	0.49

Source: Huderek-Glapska 2012

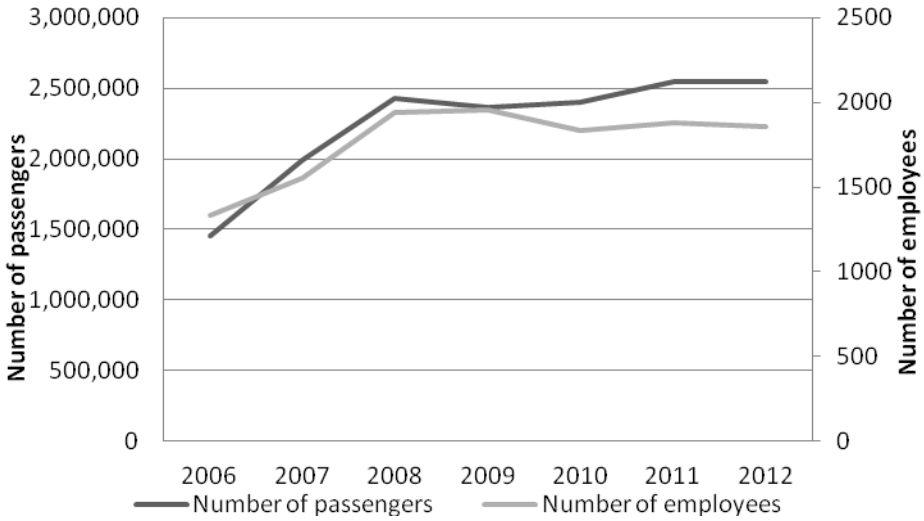
Generally, a positive correlation between the level of development of air transport and the amount of economic impact generated to the environment is observed. The following chart (Figure 1) illustrates the changes in the number of passengers and the development of direct employment at the Krakow Airport between 2002 and 2012. It is a particular period that includes the time of the biggest changes in the air transport market: 2004 moment of accession to the EU and aviation market liberalization, as well as socio-economic changes, including the opening of labor markets in the UK and Ireland, which had a very large impact on increasing the transport needs of Poles; 2009 - the financial crisis and significant drop in air transport movements. During the time period 2007-2014 many airport infrastructure projects were implemented with the use of EU fo~~u~~nds [Jankiewicz and Huderek-Glapska 2015]. For instance at Krakow Airport investments related to the expansion of the passenger terminal and airport infrastructure and communications were implemented and are still ongoing. These projects are co-financed by the European Union Cohesion Fund under the Program Infrastructure and Environment and the Malopolska Regional Operational Program for the 2007-2013 years.

Despite such large changes in the air transport market experienced by the Krakow Airport, one can observe a strong correlation (R2=0,99) between the level of development of the aviation market expressed in the number of passengers and the economic impact represented by the volume of direct employment at the airport (Figure 1). During the economic crisis in 2008, the volume of direct employment declined although not as much as the number of passengers, but then both of these variables started to grow.



Source: Own calculation based on Krakow Airport statistics and Pancer-Cybulska et al. [2014]

Fig. 1. Number of passengers and number of employees in companies directly related to the operation of Krakow Airport in 2002-2012
Rys. 1. Liczba pasażerów oraz zatrudnionych w przedsiębiorstwach bezpośednio związanych z Lotniskiem Kraków w latach2002-2012



Source: Own calculation based on Katowice Airport statistics and Pancer-Cybulska et al. [2014]

Fig. 2. The number of passengers and the number of employees at Katowice Airport in 2006-2012
Rys. 2. Liczba pasażerów oraz zatrudnionych w Lotnisku Katowice w latac h2006-2012

At Katowice Airport, the number of passengers in 2008 - 2012 was stable despite the economic crisis, which peaked in 2009 (Figure 2), while the employment declined. This was connected among other things to the reorganization of the Border Guard [Pancer-Cybulska et al. 2014]. The biggest increase in the work places occurred in 2004-2007 when the dynamic increase in the number of air traffic movements from Katowice Airport was observed due to an expansion of low cost airlines which resulted in the need for the

expansion of airport infrastructure. The analysis in 2009 and 2012 covered the period after the major changes at the Katowice Airport, which is why the number of companies operating in and around the airport and the structure of airport direct employment, did not change significantly (Table 2).

The development of air transport is likely to create the socio-economic benefits for regional economy. Promoting the development of air transport market contributes to creating positive effects in the environment in terms of creating work places. However there are also negative effects such as noise and air pollution that result from air transport activity and which should be included in the cost benefit analysis of aviation infrastructure development.

Based on data collected by a research team led by prof. Pancer-Cybulska, an analysis of the impact of air transport on economic development has been conducted and the results of which are presented below. The reference year for the data collected is 2012. Table 2 shows the results of the latest analysis of employment, compared with the results of previous studies. The airport in Katowice is the only one that occurs twice in the study. The latest analysis includes a small regional airport in Szczecin, which in 2012 handled around 350 thousands passengers.

Table 3. Employment structure at polish airports in 2009 and 2012
Tabela 3. Struktura zatrudnionych na polskich lotniskach w 2009 oraz 2012

	Poznan (2009)	Gdansk (2009)	Katowice (2009)	Katowice (2012)	Krakow (2012)	Wrocław (2012)	Szczecin (2012)
Number of passengers (mln)	1.2	1.8	2.3	2.5	3.4	1.9	0.3
Number of companies at airport	82	57	58	57	109	67	17
Employment	1076	1214	1954	1857	3061	1476	390
Employment per million passengers	897	674	850	743	900	777	1300
Employment structure:							
Airport operator and administration	39.1%	31.7%	37.5%	39.8%	50.9%	50.1%	72.1%
Handling	31.6%	29.7%	23.8%	28.2%	27.9%	18.7%	2.3%
Airlines	3.1%	6.3%	7.4%	12.9%	2.3%	6.6%	1.3%
Retail	11.0%	12.4%	12.2%	13.6%	8.7%	11.0%	3.8%
Logistic	12.1%	16.1%	15.7%	5.5%	2.6%	6.8%	5.1%
Others	3.2%	3.9%	3.5%	-	7.5%	6.7%	15.4%

Source: Own calculations based on own research and [Pancer-Cybulska et al. 2014]

The employment structure at Polish airports is not significantly different from the employment structure at other European airports. However the number of direct employment per million passengers handled at polish regional airports (Table 3) is lower than the European average which is 1034 jobs per million passengers at regional airports serving from 1 to 4 million passengers annually [ACI 2004]. The reason for this is low share of commercial activities at airports. Changes began to take place since the liberalization of air transport at the time of Polish entry into the EU, and many years must pass before the Polish aviation market can catch up to the level of development markets in Western Europe.

The structure of direct employment at the airport, to some extent depends on the type and characteristics of the airport. The one focused on serving the cargo will attract more freight and logistics companies. The airport where airlines have bases will generate employment in the entities providing services to the planes. However, there are some common features in the structure of direct employment at the airports. At the regional airports, the airport operator and administration employ about 30-50% of all employees directly associated with the operation of the airport. It is worth paying attention to their higher share in the small airport in Szczecin (72% - Table 2). This confirms the thesis that there is a minimum level of employment, which is required for the airport to operate. With the development of air traffic and passenger growth, more and more companies are interested in locating their

business at or within the airport. The hub airports such as Amsterdam Schiphol, create the so-called airport cities (Aeropolis, aerotropolis, AIRE, Airport Area) which is the cluster of companies around the airport along with extensive intermodal infrastructure [Schalaack 2009]. Wherein, this area rarely takes the form of a circle, usually entities are concentrated around the airport at irregular distances, and the factors influencing their location are primarily the availability and prices of land and buildings under lease, availability and quality of transport routes or the presence of facilities for investors.

Based on the financial data and the employment figures of the airport operator and the companies operating at the airport and within, the estimates were made of the airport economic impact on the regional development. As a variable number of employees (ΔE) and value-added (ΔX) were adopted. The results of the analysis are interpreted as a direct increase in employment and added value in the region resulting from the operation of the airport.

Direct effect generated by the airport operator and companies located at the airport and in the area within the airport is the most important and rather not debatable impact category. The direct effect of regional airports in Poland was calculated on the basis of work places and added value generated by the companies. Data on the number of employees has been derived from data collected by a research team led by prof. Pancer-Cybulska [Pancer-Cybulska et al. 2014]. The added value generated from the revenue side by the airport operator and entities directly associated with airport operation is calculated based on the number of employees in these companies and an average added value created by a single employee, with respect to the type of company activity and region in which the company is located [GUS 2014]. Results of the analysis are presented in Table 4.

Table 4. Direct economic impact of regional airports in 2012
Tabela 4. Bezpośredni ekonomiczny wpływ lotnisk regionalnych w 2012

Airport	Number of passengers (mln)	Number of companies at the airport	Direct employment ΔE_{dir}	Direct impact-value added (mln EUR) $\Delta \underline{X}_{dir}$	Direct impact per passenger (EUR)
Kraków	3.4	109	3061	81.1	24
Katowice	2.5	57	1857	51.9	20
Wrocław	1.9	67	1476	40.1	20
Szczecin	0.3	17	390	10.6	30

Source: Own calculations

Among the studied, Kraków Airport creates the largest direct economic impact on the region's economy (3061 direct jobs and 81.1 million EUR of value added in 2012) this is understandable, since it is the largest of the surveyed airports. This is another proof of the thesis that the size of the airport operation has an impact on the size of the positive effects created by an airport on its surroundings.

Beyond the direct impact there are indirect and induced effects - demand impulses that arise as a result of airport activity. The larger the number of entities operating in the airport and within the airport area the greater the number of employees and the greater value of purchases from suppliers, greater value of income from work and greater possibilities of consumption which contributes to the growth of value added level.

Due to the limitation of data availability in the calculation of the indirect and induced impacts the multipliers derived from previous study [Huderek-Glapska 2012] were used. The average value of employment multiplier was assumed at 0.75; and the average income multiplier at 0.79.

The sum of indirect and induced impact is calculated as the multiplication of the direct effect and the multiplier. The total economic impact of air transport on the development of the region's economy is calculated according to the equation (9).

$$\Delta X = \Delta X_{dir} (1+ M) \qquad (9)$$

Table 5. Indirect, induced and total economic impact of regional airports 2012
Tabela 5. Pośredni, wspomagany oraz całkowity ekonomiczny wpływ lotnisk regionalnych w 2012

Airport	Indirect and induced impact		Total impact		
	Employment $\Delta E_{indir} + \Delta E_{ind}$	Income (M EUR) $\Delta \underline{X}_{indir} + \Delta \underline{X}_{ind}$	Employment ΔE	Income (M EUR) $\Delta \underline{X}$	Income per passenger
Kraków	2296	64.1	5357	145.2	42
Katowice	1393	67.9	3250	153.8	62
Wrocław	1107	31.7	2583	71.8	38
Szczecin	293	8.4	683	19.0	63

Source: Own calculations

According to the methodology, airports contributes to the regional economy in terms of employment (ΔE) and income (Δ X). Research results reveals that, on average, polish regional airports contribute directly to the creation of 0.9% of GDP generated in the regional economy. Adding to the indirect and induced impacts the value rises to around 2%. Which is consistent with the results of European airports, by which alone the direct impact of air transport creates on average 1.1% of GDP, and the overall impact is from 0.9% to 2.4% of the regional Gross Domestic Product [Giliingwater et al. 2009]. On average, each passenger contributes directly 24 EUR per year to the region's GDP and nearly the same in an indirect and induced way. In total, one passenger handled from a regional, polish airport contributes on average to the creation of 51 EUR value added in the region per year.

THE PROBLEMS OF AIRPORT IMPACT STUDIES

The airport impact studies based on the simple input-output analysis are widely used all over the world. However there are calls in the literature about misuse of the input-output method and misinterpretation of the analysis results [Montalvo, 1998; Niemeier 2001].

A review of the limitations of input-output method is provided in the paper by Huderek-Glapska [2012]. These are mainly; lack of price effect, difficulties at the data collection stages or differences in defining and calculating each effect. In a large part of U.S. studies indirect effect is calculated on the basis of non-residents expenditure made in the region, in contrast to Europe and Canada where indirect effect is estimated using input-output multipliers.

Another limitation is the differences in the definition of the impact area of airport, which means that the indirect and induced impact is generated both in the region where the airport is located as well as across the whole country. Moreover the nature of effects varies with the increase in the scope of the study area. When the level of data aggregation is low then the effects can be interpreted as generated by the operation of airport. At the national level the same effects can be interpreted as distributive when there is a change of resource allocation. The fact that the relevant businesses are located in the airport's catchment area does not mean that in the case of the absence of an airport, these companies would stop to operate. The management probably would have chosen a different location characterized by good accessibility, for example road junction.

Since the results of impact analysis are usually based on data collected in the selected base year the outcomes of input-output study are static. Air transport is particularly sensitive to the changes in local and global economic environment. The situation on aviation market can vary significantly between study periods. Analysis conducted during the peak year may overstate test results and conversely conducting economic study during the recession may underestimate the size of the effects. The example of described situation is reflected in this article where data was collected first in 2009 year - during the crisis time and then in 2012 - the peak time when the traffic was increased associated with UEFA Championships. So there is risk that in 2009 the results were underestimated and conversely in 2012 overstated. That is why the static

nature of the results is one the main limitation of input-output analysis.

Apart the factors already stated, the most crucial problem of airport impact studies is that input-output method calculates aviation impact in gross value. All effects are taken into account (called Economic Impact as it is produced - AIIP) [Montalvo, 1998]. In the absence of the airport, the resources would be used, at least partially, in other economy sector. The question about the degree of resource utilization and thus the productivity of labour and capital therefore rises. Does the aviation industry uses resources more effectively than other industries?

The results of airport impact analysis are only part of the total impact of an airport on its surroundings. When assessing the effects generated by airport activity one must consider both the positive and negative effects of air transport operations, including the environmental cost.

IMPROVEMENTS OF AIRPORT IMPACT ANALYSIS

Input-output analysis with price effect

One of the main drawbacks of the airport impact analysis based on the simple input-output model is lack of the price effects [Niemeier 2001]. However the input-output models allow for prices analysis, although, as far as authors know, there is lack of study that would apply this extension in airport impact research.

The prices analysis also rest on the Leontief inverse and its mathematical expression (in matrix form) is as follows:

$$P = (I - A)^{-1} (l + k)$$

P denotes prices, *I* is the identity matrix, *A* is the technical coefficient matrix; *l* and *k* and denotes the labor technical coefficient and capital technical coefficient, respectively. This approach helps in quantifying the changes in prices as a result of exogenous changes in wages or rents of capital.

As it can be seen, both the demand analysis and the prices analysis have to be done separately in the input-output framework. In contrast, computable general equilibrium (CGE) models can tackle both analyses simultaneously.

Dynamic input-output analysis

Input-output models can also cope with time (Duchin and Szyld 1985; Leontief and Duchin 1986). The dynamic approach implies the elicitation of the capital accumulation process because some goods are not used in the current period but in the following ones. The dynamic version (in matrix form) of an input-output model can be written in the following manner:

$$Bx^{t+1} = (I - A + B)^{-1} x^t - D^t$$

where *B* is a coefficient matrix which denotes the amount of the production in one sector held as capital stock so as to produce outputs in other sectors. x^{t+1} is the production in the next period *(t +)*. x^t denotes the production in period *t* and D^t is the final demand in period *t*.

As in the static case, the non-singularity of the coefficient matrix of capital (B) has to be achieved ($|\beta| \neq 0$). However this is not always the case because not all the sectors supply capital goods to other sectors. So, there will be sectors whose rows in the B matrix will contain all zeros and the matrix have no inverse (Miller and Blair 2009). On the other hand, as in the case of dynamic models, dynamic input-output models require both initial conditions/values and terminal conditions/values. Despite this resemblance, both dynamic input-output models and dynamic models differ from each other in their foundations. Nonetheless, some approaches between both kinds of models can be achieved. For instance, a dynamic input-output model can be enriched by including some properties of the endogenous growth model (Los 2001). However, so far, the application of dynamic input-output models has been limited and, in contrast, dynamic models such as dynamic CGE models have been applied more widely.

Finally, input-output models also allow for an alternative approach to dynamics, the so-called "structural decomposition analyses". Briefly, the standard approach decomposes the total amount of change into several components such as changes in technology and changes in final demand over the period analyzed (Rose 1996; Miller and Blair 2009).

Computable General Equilibrium models (CGE)

CGE models can be described as a set of equations solved simultaneously to find prices at which quantity supplied equals quantity demanded (equilibrium) across all (general) markets. CGE models describe the economy using representative agents: consumers, producers, government and other institutions. Consumers allocate time to employment and leisure and income to consumption and savings to maximize utility. Producers combine labour and capital inputs to maximize profits, whereas government collects tax revenue to finance expenditure and make transfers to households and investors. CGE models can broadly be distinguished according to their level of spatial detail (i.e. national, multi-country, regional or multi-regional) or to time dimension (static versus dynamic).

Table 6. Comparison Input-Output and CGE
Tabela 6. Prównanie wejścia-wyjścia oraz CGE

	Input-Output	CGE
Major output	**Range of macro-economic variables**: GDP, employment, income	**Range of macroeconomic variables:** Relative prices, employment, consumption, income, investment, taxes, imports, exports, Industry output, GDP, welfare
Advantages	Provides measure of macro-economic impacts of interest to policy makers	Provides measure of macro-economic impacts of interest to policy makers, Non-linear behavior, Flexible structure, Resource constraints
Limits	Linear structure Tend to exaggerate economic impact (does not allow constraints on various factors) No allowance for environmental externalities Does not provide clear and direct measure of net benefits (costs)	High data requirements, determination of parameters and elasticity values, highly complex, not good for monetary policies.
IO vs CGE	Complexity: medium. May be more practical than CGE for analyzing the path through which changes in sector travel to affect other sector as well as linkages between sectors.	Complexity: large IO can be used as a base for CGE Allowance for constraints provide more realistic modeling of output than IO and more comprehensive approach to the estimation of regional economic impacts Unlike IO specific assumptions about the behavior of consumers, producers and investors

Source: (adapted from MOTOS, 2007 and Wallis, 2009)

CGE models are good for analyzing policies that affect different sectors in different ways. They can help capture the impacts of a policy on factor (capital, labor and land); on commodity markets; on households' types and on different regions. CGE models are also good for understanding the welfare and distributional impact of alternative policies.

CGE models have been extensively used since the 1970s for the evaluation of trade and fiscal policies and for the quantification of the impacts of various shocks on the economy at both national and regional levels. The application of CGE models on airport investments is much more recent (Madden, 2003; Deloitte Access Economics, 2013; PwC, 2014).

Table 4 highlights the main differences between IO and CGE. CGE models have a solid microeconomic foundation and are capable of capturing the indirect and feedback effects of a wide range of possible policy change without excessive simplification and aggregation. CGE models which takes into account and allows for the negative as well as the positive impacts of policy changes or

shocks. Criticisms of CGE models include the reliance on the elasticity parameter values and the lack of financial or monetary aspects.

CONCLUSIONS

Operation of an airport undoubtedly creates economic benefits for the economy. This is confirmed by the analysis of international airports all over the world, and also by national studies presented in this article. An airport together with companies operating within its surroundings create demand effects that results in creating work places and income. This significant impact represent around 2% of GDP of regional economy. On average, one passenger handled from a regional airport contributes to the creation of around 51 EUR of regional income per year. This means that if one airline carries an average of 20 thousand passengers from the regional airport on one route per year, it will contribute to the creation of around 1 million EUR income per year.

Significant economic effect created by the operation of an airport in a region is an important argument in decisions concerning the expansion of existing airport infrastructure and creating a new one. However, the input output analysis in addition to other drawbacks does not include information on the financing of an infrastructure project. Airports in Poland, are in majority public ownership and conducting public investment is associated with increasing public debt. The profitability of investment in infrastructure will reveal in a long term analysis or study. However building the airport to become the main driving force of the regional economy development if there are no other influential factors such as positive economic and political conditions can cause that the potential of the region not to be fully exploited (sentence is too long, needs to be rewritten). Therefore, the objective of undertaking investments in infrastructure will not be achieved and the allocation of public money will be inefficient. Transport infrastructure is only one of many factors affecting the development of a region and it is not the sole and sufficient condition for generating development.

Therefore, it is important to properly and accurately recognize the impact of air transport on the environment. If the significance of the airport for the region is an important argument in the infrastructure development decision process the one should strive to ensure thi impact is precisely reflected. To this end, improvements of the input-output method including consideration of the effect of prices and the dynamics have bee proposed. The comprehensive assessment of airport operation and expanding its infrastructure requires comparing the economic benefits with economic costs.

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MODELOWANIE WPŁYWU TRANSPORTU LOTNICZEGO NA GOSPDOARKĘ - PRAKTYKA, PROBLEMY I PERSPEKTYWY

STRESZCZENIE. **Wstęp:** Tematyka roli transportu lotniczego w rozwoju gospodarki regionalnej jest bardzo aktualna w dzisiejszych czasach, kiedy realizowanych jest wiele projektów inwestycyjnych w infrastrukturę lotniskową, z wykorzystaniem środków finansowych z funduszy Unii Europejskiej. Rosnące potrzeby transportowe i wzrost dochodów ludności, oznaczają, że rynek transportu lotniczego rozwija się i będzie rozwijać się w przyszłości. Temu wzrostowi towarzyszą korzyści bezpośrednie i pośrednie, które pojawiają się w otoczeniu społeczno-ekonomicznym portu lotniczego oraz w całej gospodarce. Pomiar tych korzyści jest istotny, ponieważ decyzje podejmowane w odniesieniu do transportu lotniczego mają wpływ na lokalną i regionalna gospodarkę. Najpowszechniej stosowanym narzędziem do pomiaru efektów związanych z funkcjonowaniem lotniska jest analiza nakładów i wyników. Celem artykułu jest przedstawienie charakterystyki metody nakładów i wyników, ukazanie jej zastosowania w pomiarze społeczno-ekonomicznych efektów transportu lotniczego w Polsce - kraju o największej dynamice rozwoju rynku lotniczego oraz przedstawienie możliwych ograniczeń metody wraz z propozycją jej ulepszeń.
Metody: Narzędziem zastosowanym w badaniu jest metoda nakładów i wyników za pomocą której dokonuje się pomiaru zmian w gospodarce wywołanych aktywnością transportu lotniczego.
Wyniki: Na tle wyników analizy wpływu polskich portów lotniczych na gospodarkę kraju, przeprowadzonej w 2009 roku, ukazano rezultaty najnowszych badań opartych na danych odnoszących się do 2012 roku. Przedmiotem badań są porty lotnicze w Krakowie, Katowicach, Wrocławiu i Szczecinie. Następnie ukazano ograniczenia metody nakładów i wyników i zaproponowano ulepszenia tego modelu.
Wnioski: Właściwy pomiar wpływu funkcjonowania portu lotniczego i efektów wynikających z podejmowania inwestycji lotniskowych na gospodarkę regionalną, prowadzi do bardziej skutecznej polityki rozwoju sektora transportu lotniczego i polityki rozwoju regionalnego. W kolejnych badaniach społeczno-ekonomicznych efektów transportu lotniczego zalecane jest zastosowanie zaawansowanej metody nakładów i wyników.

Słowa kluczowe: port lotniczy, rozwój regionalny, analiza nakładów i wyników.

MODELLIERUNG DES EINFLUSSES DES FLUGTRANSPORTS AUF DIE WIRTSCHAFT - PRAXIS, PROBLEMSTELLUNGEN UND PERSPEKTIVEN

ZUSAMMENFASSUNG. Einleitung: Die Thematik der Bedeutung des Lufttransports für die Entwicklung der Regionalwirtschaft ist gegenwärtig sehr aktuell, zumal viele Investitionsprojekte innerhalb der Luftfahrt- und Flughafen-Infrastruktur mit Inanspruchnahme von Finanzmitteln aus der Europäischen Union realisiert werden. Der wachsende Transportbedarf und die Erhöhung von Einkommen bei der Bevölkerung haben nämlich es zur Folge, dass der Lufttransport-Markt einer ständigen Entwicklung unterliegt und auch in Zukunft ihr unterliegen wird. Der Entwicklungs- und Wachstumstrend wird von mittel- und unmittelbaren Vorteilen begleitet, die im sozial-wirtschaftlichen Umfeld eines Flughafens und in der Gesamtwirtschaft in Erscheinung treten. Da die den Lufttransport anbetreffenden Entscheidungen die Lokal- und Regionalwirtschaft beeinflussen, scheint die Bewertung dieser Vorteile sehr relevant zu sein. Als das meist angewendete Tool für die Bewertung der mit Funktionsausübung eines Flughafens zusammenhängenden Effekte gilt die Aufwands- und Ergebnisanalyse. Das Ziel des Artikels ist es, die Charakteristik der Aufwands- und Ergebnismethode darzustellen, ferner deren Anwendung für die Auswertung der sozial-ökonomischen Effekte des Lufttransports in Polen, dh. im Lande von der höchsten Entwicklungsdynamik innerhalb des Flugtransport-Marktes zu projizieren und die potenziellen Einschränkungen bei der Anwendung der betreffenden Methode, sowie die Vorschläge für ihre Verbesserung aufzuzeigen.
Methoden: Das in der Erforschung des Problems angewendete Tool ist die Aufwands- und Ergebnisanalyse, mit Hilfe deren die Bewertung der infolge der Betätigung des Lufttransports erfolgten Veränderungen innerhalb der Wirtschaft zustande kommt.

Ergebnisse: Gestützt auf die Ergebnisse der 2009 durchgeführten Analyse des Einflusses polnischer Flughäfen auf die Volkswirtschaft projizierte man die Resultate der neuesten Forschungen, die auf die Daten vom Jahre 2012 zurückzuführen sind. Der Untersuchungsgegenstand sind die Flughäfen in Kraków, Katowice, Wrocław und in Szczecin. Demzufolge stellte man auch die Einschränkungen bei der Anwendung der Aufwands- und Ergebnismethode dar und schlug man brauchbare Verbesserungen des betreffenden Modells vor.
Fazit: Die richtige Bewertung des Einflusses der Funktionsausübung eines Flughafens und der Effekte, die aus der Inangriffnahme von Flughafen-Investitionen der Regionalwirtschaft zugunsten resultieren, führt zur Handhabung einer mehr effektiven Politik bei der Entwicklung des Lufttransport-Sektors und der Politik der erfolgreichen Regionalentwicklung. In den weiteren, die sozial-wirtschaftlichen Effekte des Lufttransports anbetreffenden Forschungen wird die Anwendung einer fortgeschrittenen Aufwands- und Ergebnismethode empfohlen.

Codewörter: Flughafen, Regionalentwicklung, Aufwands- und Ergebnisanalyse

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