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APPLYING THE METHOD OF MEASURING AIRPORT PRODUCTIVITY IN THE BALTIC REGION

Ilona Jaržemskienė

Transport Research Institute, Vilnius Gediminas Technical University, Plytinės g. 27, LT-10105 Vilnius, Lithuania
E-mail: ilona.jarzemskiene@vgtu.lt

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Abstract. The author of the article describes the theoretical assumptions of the DEA method used for measuring the productivity of airports described in the article 'Research into the methods of analysing the productivity indicators of transport terminals' (Jaržemskienė 2009). The essential insights presented in the above mentioned paper reveal that Data Envelopment Analysis (DEA) is a relatively new 'data oriented' approach to evaluating the performance of the so-called Decision Making Units (DMU) that convert multiple inputs into multiple outputs. The article focuses on the findings of the study carried out by the author in accordance with those assumptions. Research represents the Data Envelopment Analysis (DEA) method testing 15 selected airports situated in the Baltic Region, including Vilnius, Kaunas, Palanga, Riga, Tallinn, St. Petersburg, Helsinki, Turku, Stockholm, Malme, Copenhagen, Hamburg, Gdansk, Warsaw and Minsk. Airport productivity indicators are ranked considering importance and using the method of Delphi expert survey made of two rounds. The author presented the following indicators (expressed as 'ratio') as the major ones estimated by PAX/LAND, AIR/LAND, PAX/AIR, PAX/RW, PAX/RWA, GA and INTER experts. The succeeding indicators were introduced by PAX/TERMAREA, PAX/GATES, AIR/RW, AIR/RWA, AIR/TERMAREA, AIR/GATES, FR/LAND and FR/RW. 10 indicators were accepted as the most important and selected from the current set in the following sequence: AIR/LAND, AIR/RW, PAX/RW, PAX/LAND, AIR/RWA, PAX/AIR, PAX/RWA, AIR/TERMAREA, PAX/GATES and PAX/TERMAREA. AIR/LAND and AIR/RW were submitted as two main indicators. The acronyms are explained as follows: LAND – airport area, RWA – runway length, PAX – the number of passengers, AIR – the number of aircraft take-offs and landings, RW – the number of runways, GATES – the number of gates, FR – the amount of freight served, TERMAREA – the area of passenger terminal, GA – a general aviation market share of airport served aircraft by percentage, INTER – the percentage of international passengers considering all passengers served by airports. After two key productivity indicators were chosen conducting the expert survey, airport productivity was compared applying the DEA method.

Keywords: data envelopment analysis, terminal, evaluation, productivity, airport, passengers, gates, runway.

1. Introduction

The author of the article discusses the theoretical assumptions of the DEA method used for measuring the productivity of airports explained in the article 'Research into the methods of analysing the productivity indicators of transport terminals' (Jaržemskienė 2009). The article deals with the findings of the study carried out in accordance with those assumptions.

The essential insights presented in the above mentioned paper reveal that Data Envelopment Analysis (DEA) is a relatively new 'data oriented' approach to evaluating the performance of the so-called Decision Making Units (DMU) that convert multiple inputs into multiple outputs. The method of Data Envelopment Analysis was first introduced by Rhodes in his dissertation. When evaluating the efficiency of educational programmes for disadvantaged students instead of collecting numerous pieces of information required for evaluating the inputs and results of concrete figures, Rhodes applied DEA. Parametric analysis in this particular case could be hardly applied due to the existence of multiple factors defining inputs and multiple criteria for determining output. Hence being incepted, DEA has grown into a powerful tool for evaluating the productivity of sophisticated technological operations. As pointed out in Cooper *et al.* (2006), recent years have seen a widespread application of DEA in evaluating the productivity of the technological processes across a variety of industry sectors. The generic and flexible nature of the aforementioned DMUs faces difficulties in coming up with a single definition of the concept (Cooper *et al.* 2004; Zhu 2002). One of the specific features of the Data Envelopment Analysis method is that this technique requires only very few assumptions. The sector of transport was first to bring in DEA into public passenger transport (Kerstens 1996; Pina, Torres 2001; Boame 2004) and railways (Coelli, Perelman 1999). Ross and Droge (2004) employed DEA for evaluating the productivity of distribution systems. Tongzon (2001), Itoh (2002), Turner *et al.* (2004) used DEA for evaluating the productivity of airports. Scheraga (2004), Capobianco and Fernandes (2004) applied DEA for measuring the productivity of air operators.

The sector of air transport introduced DEA in the late 1990's; such practice was pioneered by Gillen and Lall (1997, 2001), Murillo-Melchor (1999) and Salazar de la Cruz (1999). The evidence suggesting the application of DEA in the transport sector by Lithuanian researchers has not been found.

The examples involving the application of DEA methods can be observed in Abbott and Wu (2002), Adler and Berechman (2001), Bazargan and Vasigh (2003), Fernandes and Pacheco (2005), Sarkis and Talluri (2004).

The article provides the evaluation of productivity indicators applied by 15 selected international airports applying the DEA method. The significance of the indicators was evaluated using the Delphi method. 15 experts were interviewed anonymously in two rounds. Following the first round, the experts independently identified additional indicators that became the subject of the interviews in the second round. After ranking airport productivity indicators, the productivity of airports was compared employing the DEA method according to two key indicators.

Similar attempts to assess the productivity of airports were made before by Abbott and Wu (2002) in Australia; by Parker (1999) in Great Britain; by Gillen and Lall (1997); Bazargan and Vasigh (2003), Sarkis, (2000), Sarkis and Talluri (2004) in the USA; by Martín and Román (2001) in Spain; by Fernandes and Pacheco (2001, 2002, 2005) in Brazil; by Yoshida (2004), by Yoshida and Fujimoto (2004) in Japan. However, only a few researchers made attempts to investigate the issue on a larger than the national scale, for example, at European (Pels *et al.* 2003) or international (Adler, Berechman 2001; Oum, Yu 2003, 2004) level.

2. Features on Method Application

Since productivity is perceived as the ratio between input and positive and negative output, it is greatly important to identify the main inputs and outputs in the airport cases. Another aspect is to identify the relationship between what inputs and outputs are relevant to determining productivity. To define input and output indicators that best reflect the performance of airports, it is necessary to sort out these indicators taking into account their relevance. The analysis of literature showed no consensus on the importance of these indicators. Also, it is noteworthy that the relevance of these indicators in various regions is different. For example, what is applicable to the airports in Australia, it is not suitable for South American airports, or those applicable to North American airports will not work in Western Europe. An important point is that Europe is not homogeneous in this respect, and therefore things applicable to the Mediterranean region do not fit for Scandinavia and the Baltic Sea region. Thus, in order to perform the assessment of the indicators, first, it is necessary to define the geographic scope and select assessment methodology (Fig. 1, Tables 1 and 2).

A very important task is determining the values that best describe airport productivity. Pathomsiri *et al.* (2006) systematized these values in his study: RW – the number of runways. This number plays a huge role in attracting more traffic. However, it must be noted that the number of runways, as well as inputs only, cannot generate output. The number of runways and landing paths is usually assessed as inputs in the theory of productivity.

RWA – runway length. Similarly to the number of runways, runway length is also important for attracting more flights because the types of planes allowed to land depend on runway length. As for Vilnius International Airport, although theoretically runways are adequate even for Boeing 757, only few of which have landed throughout the history of the airport, it is important to note that according to the characteristics of the existing runway and landing path, such planes can take off and land with only a low tank filling ratio, including incomplete tanks, a low number of passengers and empty cargo sectors. Thus, path length determines the ability to attract a larger aircraft, which in turn, brings more passengers and cargo themselves compared to a smaller aircraft. On the other hand, according to the flight specifications of certain routes, a small aircraft is not economical to be allowed to serve. For example, transatlantic flights are dominated by a large aircraft,

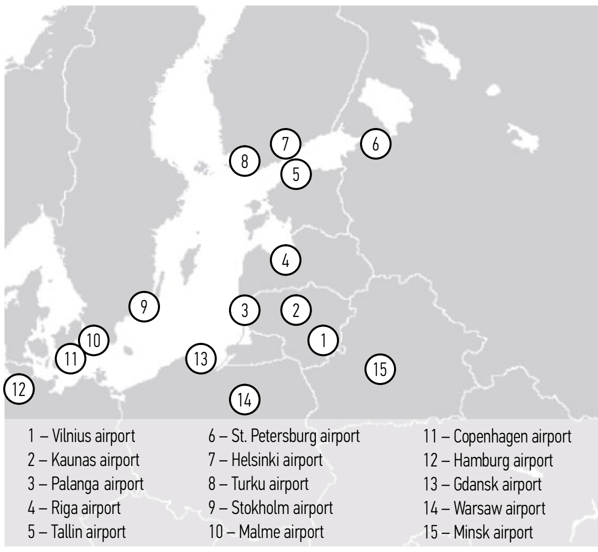

Fig. 1. The set of Airports

Table 1. The parameters of the airports selected for study (1)

	Number	1	2	3	4	5	6	7	8
	Title	Vilnius	Kaunas	Palanga	Riga	Tallinn	Saint Petersburg	Helsinki	Turku
Inputs	Measure								
LAND	km^2	3.26	5.06	1.60	4.20	3.50	4.60	5.20	2.70
RW	units	1	1	1	1	1	2	3	1
RWA	m	2515	3250	2280	3200	3200	3500	3440	2500
TERMAREA	m^2	37462	7378	2000	3000	4000	4350	5050	2590
GATES	units	14	15	2	23	15	16	12	12
Outputs									
AIR	units	37839	5698	1500	80000	41654	95000	183796	11000
PAX	units	2048000	410165	100000	3690449	1811536	7070000	13427000	318000
Indicators									
AIR/LAND		11607.1	1126.1	937.5	19047.6	11901.1	20652.2	35345.4	4074.1
AIR/RW		37839.0	5698.0	1500.0	80000.0	41654.0	47500.0	61265.3	11000.0
PAX/RW		2048000.0	410165.0	100000.0	3690449.0	1811536.0	3535000.0	4475666.7	318000.0
PAX/LAND		628220.9	81060.3	62500.0	878678.3	517581.7	1536956.5	2582115.4	117777.8
AIR/RWA		15.0	1.8	0.7	25.0	13.0	27.1	53.4	4.4
PAX/AIR		54.1	72.0	66.7	46.1	43.5	74.4	73.1	28.9
PAX/RWA		814.3	126.2	43.9	1153.3	566.1	2020.0	3903.2	127.2
AIR/TERMAREA		1.0	0.8	0.8	26.7	10.4	21.8	36.4	4.2
PAX/GATES		146285.7	27344,3	50000,0	160454.3	120769.1	441875.0	1118916.7	26500.0
PAX/TERMAREA		54.7	55.6	50.0	1230.1	452.9	1625.3	2658.8	122.8

Table 2. The parameters of the airports selected for study (2)

	Number	9	10	11	12	13	14	15
	Title	Stockholm	Malme	Copenhagen	Hamburg	Gdansk	Warsaw	Minsk
Inputs	Measure							
LAND	km^2	4.80	4.90	11.80	5.70	3.20	5.40	4.70
RW	units	3	2	3	2	1	2	1
RWA	m	3301	2800	3500	3666	3000	3500	3500
TERMAREA	m^2	8000	7600	8600	6500	4300	6500	5400
GATES	units	32	25	64	38	20	15	15
Outputs								
AIR	units	365140	25038	260391	200000	54000	180500	19000
PAX	units	18136000	1748000	21530000	12840000	1954000	9436958	1010695
Indicators								
AIR/LAND		76070.8	5109.8	22067.0	35087.7	16875.0	33425.9	4042.6
AIR/RW		121713.3	12519.0	86797.0	100000.0	54000.0	90250.0	19000.0
PAX/RW		6045333.3	874000.0	7176666.7	6420000.0	1954000.0	4718479.0	1010695.0
PAX/LAND		3778333.3	356734.7	1824576.3	2252631.6	610625.0	1747584.8	215041.5
AIR/RWA		110.6	8.9	74.4	54.6	18.0	51.6	5.4
PAX/AIR		49.7	69.8	82.7	64.2	36.2	52.3	53.2
PAX/RWA		5494.1	624.3	6151.4	3502.5	651.3	2696.3	288.8
AIR/TERMAREA		45.6	3.3	30.3	30.8	12.6	27.8	3.5
PAX/GATES		566750.0	69920.0	336406.3	337894.7	97700.0	629130.5	67379.7
PAX/TERMAREA		2267.0	230.0	2503.5	1975.4	454.4	1451.8	187.2

and with insufficient runway length there is no means possible to attract this market segment. The length of runways and landing paths in the productivity theory is usually considered as inputs.

LAND – airport area. Even though the area of the airport is not directly involved in creating the added value, it is often assessed as the one of the major inputs. On the one hand, it is a reserved territory for new runways and landing paths or the extension of the existing runways and landing paths. On the other hand, an airport with a larger area may provide more additional non-aviation services such as hotels, business and conference centres, etc. These additional non-aviation service centres themselves attract large flows of passengers and airports become attraction centres of business meetings. They are highly relevant in international business when company representatives of several countries decide to meet at a neutral airport; in that case, they even do not need to go to another country or city. The area of the airport is also very important to terminals, more specifically, to their size and layout. Larger terminals likely to attract more passengers and adequate services for transit passengers are created. When the area is inadequate, restrictions on the size of the terminal appear which in turn imposes a limit on the markets.

PAX – the number of passengers. This is one of the main output indicators. GATES – the number of gates. FR – the amount of freight served (in tons). TERMAREA – the area of passenger terminal (in square meters). AIR – the number of aircraft take-offs and landings. It is also one of the main indicators for output, although it does not reflect it so well as the number of passengers. Given that the aircraft can vary in size and passenger load on board may be different, the effect is often insignificant. On the other hand, eventually, when the load of the aircraft is not full, the airline chooses a smaller aircraft, reduces the number of flights or even cancels the flight.

Further indicators characterize airport productivity expressed as the ratio between input and output indicators. For example, PAX/LAND value indicates the number of passengers per single unit of the airport land area. AIR/LAND shows the number of aircraft take-offs and landings per single airport unit. It seems to be clear that a certain time spell is necessary to evaluate the indicators of output and make appropriate comparisons. The researched literature mainly uses the spell of one year with the starting point of the calendar year. The main reason for this is access to statistical information.

Different airports have different accounting indicators – data are stored and calculated on a daily basis and sorted by calendar days of the week or by the month. However, annual reports that airports become available to general public is a source of the most popular and available information. Thus, PAX/LAND units of measurement indicate the number of passengers per year per square metre of the airport area. AIR/LAND is measured by take-offs and landings per year per square metre of the airport area. PAX/AIR is the average number of passengers per one take-off and landing of one aircraft. Such productivity indicator is derived, because it consists essentially of the ratio of two outputs. The unit of measurement is the number of passengers carried per year per one take off and landing of the aircraft. Both taking off and landing in the English language are used as movement; moreover, research literature does not distinguish take-offs and landings. PAX/RW is a value that describes the number of passengers per one runway – landing path. This value clearly reflects the exploitation of airport infrastructure; however, without an assessment of runway lengths, it is natural that airports with the same number but longer runways are likely to be more productive in terms of this value because they can land bigger planes. PAX/RWA is the value that already involves assessing the length of runway and landing paths, and therefore can be more reliable in reflecting productivity.

Analogically to these values, the other parameters describing inputs and outputs can be measured. For example, to describe the characteristics of the market, Pathomsiri *et al.* (2006) introduced additional parameters such as general aviation (GA) – the market share of the airport served aircraft by percentage. General aviation involves an essentially small aircraft, including a private aircraft, air taxis, etc. This aircraft does not generate the same output as the number of passengers, but their service and passenger-related services often generate significantly larger revenue than traditional aircraft service. In addition, lower efficiency standards are set for general aviation service rather than for conventional aircraft. General aviation employs the principle of non-scheduled routes. Thus, in this respect, such service is easier.

To assess the characteristics of the market, the INTER value is also introduced meaning the percentage of international passengers in all passengers served by airports. However, this value may have greater significance in the United States where most of the passengers travel on local flights. Furthermore, it is related to border crossings and security procedures that are different in local and international flights. The situation is different in Europe because the vast majority of flights are international, from one country to another. This is mainly due to the geopolitical features of Europe where there are many small countries in a relatively small but densely populated area. A greater demand for travel on local routes is visible only in Germany, France and Spain, although with the growing popularity of high-speed trains, this need decreases each year.

In order to describe the management and ownership characteristics of airport productivity, Pathomsiri *et al.* (2006) introduced MANAGE value and the binary system principle – zero and one. Two types of airports have been distinguished. The first one is public property and the second one – private property. Private airports are more likely to have more reasons to be productive than public ownership, but at the same time, they have higher risk because they do not get subsidies from public funds. Thus, the airports that are privately owned and the primary goal of which is profit generation, are given Coefficient 1, whereas public airports, the main objective of which is meeting the needs of society, are given Coefficient 0.

Overall, to conduct a similar study, several methods are applied by researchers all over the world. The most common and cheapest method is:

1. Held (or sometimes referred to as secondary) data analysis – the so called desk research – gathering and analyzing information from a variety of secondary sources. This type of analysis is generally performed at the initial assessment stage, for example, when analysing the reports of other evaluations and (or) programme monitoring data.
2. A questionnaire survey is a quantitative method for achieving a representative perception of a certain situation, social attitude and behaviour using the questionnaire prepared in advance. Evaluation can be performed by surveying various institutions, programme beneficiaries and other target groups. Depending on the number of target group members, a certain amount of participants to be surveyed are chosen in order to obtain a representative sample with respect to the whole target group. This scientific method is quite popular, although expensive, but it applies better when the set of the surveyed is large enough. It is particularly suitable for individuals, for example, assessing the evaluation of consumers or a number of enterprises. It is less suitable for airports because the set of the surveyed in the selected geographical area is not large enough.
3. Interviewing is a qualitative research method used for obtaining information from one or more respondents mostly by a direct interview, on the phone or by e-mail. Interviews are generally conducted involving the most important interested groups at various stages of assessment (for example, the initial interviews– at the introductory stage of evaluation, comprehensive (depth) interviews – at the main stage of assessment).
4. A case study is a detailed study of a single event or case and may be useful for examining some specific cases that must be well chosen and representative within the process of evaluation.
5. Expert opinion or expert panel is the analysis of the opinion of certain experts as that of a data source. The experts are chosen based on their skills, knowledge and experience in a certain area. They can be interviewed during evaluation in order to answer questions about evaluation.

In our case, the method for expert opinion was selected as the most reliable. However, it is very important to avoid bias in experts. It is assumed that the best experts are the same employees of the Baltic Sea region airports working in strategic management chains. In fact, they are most likely to be biased as when ranking factors they can give priority to the factors their airport has the best position. On the other hand, if all the experts of the surveyed airports are interviewed, then, due to natural distribution, this risk can be rejected.

Thus, 15 airports were selected in the whole Baltic Sea region. For the expert survey, it was decided to interview 15 experts representing the middle or higher airport management level.

The Delphi method was selected from the submethods applied for the expert survey. The Delphi method was developed in 1950–1960 by RAND Corporation. It is based on the opinions of independent experts. This is a systematic interactive sociological approach, the original purpose of which was forecasting science and technologies. Later, the method was introduced in the fields of economy, health and education. Despite some shortcomings, the Delphi method is now quite widely applied in various areas for forecasting and structural analysis.

The main elements of the Delphi method are as follows:

- The structure of available information. The study collects the responses of experts to the questionnaire.
- Purposefully selected experts answer questionnaires. Typically, a study is carried out at several stages. The data obtained at each stage is carefully analysed. The investigator summarizes responses, adjusts the questionnaire and forwards it to the group of experts. The same experts are interviewed repeatedly following the adjusted questionnaire. In the course of this process, response options are reduced to a minimum and thus the ‘best’ option of the solutions is found. The process ends by reaching a preliminary foreseen criterion, for example, the number of stages after reaching consensus, the unanimity of results, etc.
- The head of the survey coordinates the interaction with experts, information collection, eliminates the least significant answers.
- Continuous feedback. If necessary, expert comments on the solutions may be collected additionally. The participants of the study are provided with the opportunities to comment on their choice, solutions to other participants of the study and the final result. Each time, they can review their previous decisions. However, the method forbids discussing back-dated inappropriate decisions.
- The anonymity of participants that are usually guaranteed anonymity. They are not identified even at the end of the study. This keeps the experts away from discussions on personalities or authorship, and, to some extent, relieves from personal bias, which makes it possible to freely express their opinions, voice their criticisms and change their opinion if necessary. Thus, the study process eliminates negative effects that are present using a ‘face-to-face’ approach.

Traditionally, the Delphi method is used for achieving a consensus at some point. The person coordinating the study conducted applying the Delphi method interacts with the specifically selected experts due to the fact that they have knowledge of the investigated matter, and therefore able to express a professional opinion or a point of view. The coordinator sends questionnaires to the experts. If they agree and follow instructions, they submit their opinions. The received responses are analysed. An accurate analysis of responses and arguments is essential, particularly in the cases of controversial or extreme opinions. The original opinion that sometimes differs from that of other experts and is significantly argued can become a significant turning point for a consensus. It is like an anonymous debate until a consensus is reached, the process is continued in the form of theses and antithesis. Work is gradually in progress in the direction of synthesis until a consensus is reached. The process usually involves three or four stages until a consensus on a relevant issue is reached.

The method is perfectly applied to distant expertise (online or by e-mail). This is the way discussions on important issues may be conducted including geographically distant experts residing in different cities, countries or even continents. In addition, since data are already in an electronic form, they can be easily and rapidly processed. The method can be adapted to the face-to-face survey and is applied in full or limited to a mini-version of Delphi. The following modifications are permitted: Internet conferencing, a hierarchical panel structure, the use of inner simulation.

The method tends to be used in cases where expert opinions are inevitable. The experts participating in the study generally recognize that the method is suitable and effective in order to obtain relevant information in a collective process. Although the results are obtained intuitively and the validity of the method is still being tested, it is argued that the Delphi method provides the most accurate results, since the method is designed for high-level professionals. The objectivity of the results is guaranteed by competent expert opinions and changes in those opinions over time.

The summary of the method applied in the study provides that:

- for evaluation purposes, 15 experts was selected;
- evaluation was carried out applying a 10-point system (10 – significant 1 – insignificant);
- evaluation included two rounds;
- in the first round of evaluation the experts can add additional productivity indicators upon their choice;
- following the first evaluation, 10 indicators are selected (those included additionally by the experts are also evaluated);
- the experts are additionally asked to repeatedly evaluate 10 indicators.

Tables 3 and 4 show the results evaluated by Delphi in the first and second round, respectively.

Figs 2 and 3 present the range of productivity indicators following first and second assessment. After the first round, the experts are suggested the following indicators:

- PAX/TERMAREA – the ratio of the number of passengers to the passenger terminal area;
- PAX/GATES – the ratio of passengers to the number of gates;
- AIR/RW – the ratio of the number of the taken-off and landed aircraft to the number of runways;
- AIR/RWA – the ratio of the number of the taken-off and landed aircraft to runway length;
- AIR/TERMAREA – the ratio of the number of the taken-off and landed aircraft to the terminal area;
- AIR/GATES – the ratio of the number of the taken-off and landed aircraft to the number of gates;
- FR/LAND – the ratio of handled cargo to the land area;
- FR/RW – the ratio of handled cargo to the number of runways.

Table 3. The results evaluated by Delphi in the first round

Indicator / Expert	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Average
Main Indicators																
PAX/LAND	10	6	6	4	10	8	6	10	5	10	2	5	3			5.67
AIR/LAND	9	5	7	3	9	6	5	7	10	8	10	6	6	9	10	7.33
PAX/AIR	6	4	8	8	8	7	8	6	4			4	5	1	1	4,67
PAX/RW	5	3	2	10		5	7	9	3	9	9	3	4	10	9	5.87
PAX/RWA		10	1	9	7	4	4	5	2	1	3	7	2	2	8	4.33
GA				2	6	3	1	8	1	7	1		1		2	2.13
INTER				1			2									0.20
Indicators suggested by experts																
PAX/TERMAREA	7	2	4			9		4		6				5		2.47
PAX/GATES	8	1	3		1	10	9				8	8		4		3.47
AIR/RW	4	9	10	7	5	1	10		9	5	7	10	8	8	7	6.67
AIR/RWA	3	8	9	6	4		3	1	8	3	6	9	7	7	4	5.20
AIR/TERMAREA		7		5	3			3	7	4	5	2	9	6	6	3.80
AIR/GATES	2				2	2			6		4		10		5	2.07
FR/LAND								2		2		1		3		0.53
FR/RW	1		5												3	0.60

Table 4. The results evaluated by Delphi in the second round

Expert \ Indicator	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Average
AIR/LAND	9	5	7	3	9	6	5	7	10	8	10	6	6	9	10	7.33
AIR/RW	4	9	10	7	5	1	10	2	9	5	7	10	8	8	7	6.80
PAX/RW	5	3	2	10	2	5	7	9	3	9	9	3	4	10	9	6.00
PAX/LAND	10	6	6	4	10	8	6	10	5	10	2	5	3	3	2	6.00
AIR/RWA	3	8	9	6	4	2	3	1	8	3	6	9	7	7	4	5.33
PAX/AIR	6	4	8	8	8	7	8	6	4	2	2	4	5	1	1	4.93
PAX/RWA	3	10	1	9	7	4	4	5	2	1	3	7	2	2	8	4.53
AIR/TERMAREA	2	7	5	5	3	3	2	3	7	4	5	2	9	6	6	4.60
PAX/GATES	8	1	3	2	1	10	9	8	1	7	8	8	1	4	3	4.93
PAX/TERMAREA	7	2	4	1	6	9	1	4	6	6	4	1	10	5	5	4.73

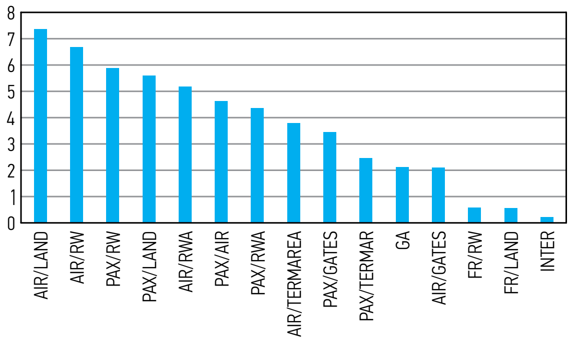

Fig. 2. Productivity indicators following first assessment

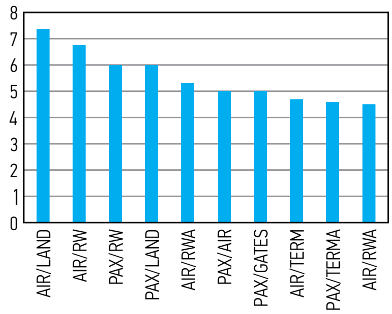

Fig. 3. Productivity indicators following second assessment

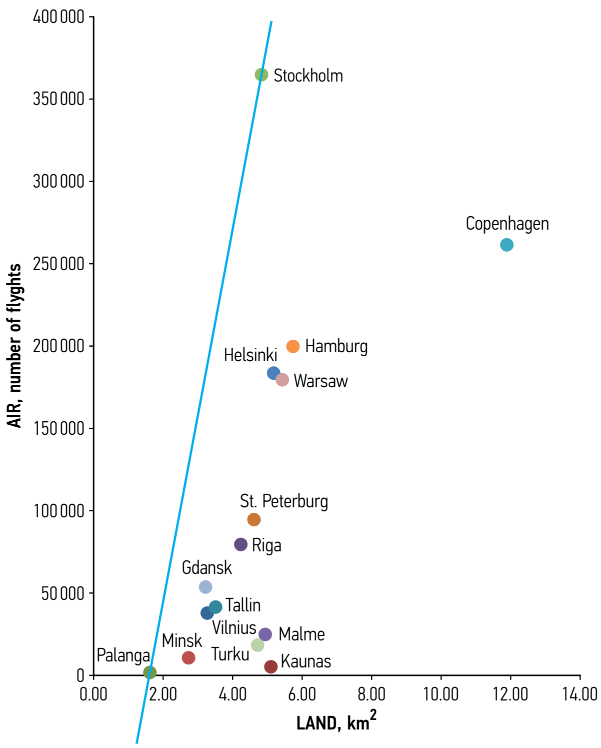

Fig. 4. DEA analysis based on AIR/LAND ratio

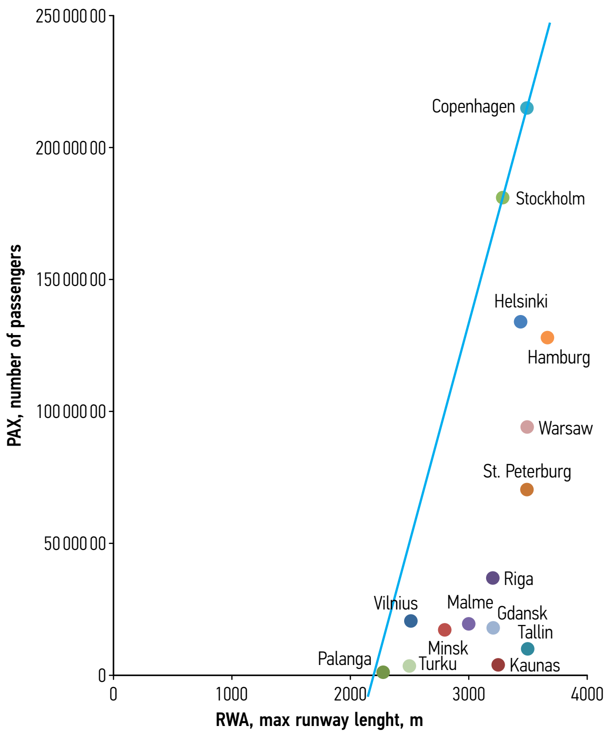

Fig. 5. DEA analysis based on PAX/RWA ratio

Following the second round of the Delphi survey, AIR/LAND and AIR/RW indicators were selected as the most important for describing productivity.

Airport productivity determined applying the DEA method is shown in Figs 4 and 5.

Palanga and Stockholm airports are the leading ones considering productivity based on AIR/LAND ratio. Copenhagen has the lowest productivity based on AIR/LAND ratio.

The DEA evaluation method and AIR/LAND indicator present that the productivity limit of the 15 surveyed airports is the productivity derivative of Palanga and Stockholm airports.

DEA analysis based on PAX/RWA ratio showed that the productivity limit of the 15 surveyed airports is the productivity derivative of Copenhagen and Stockholm airports. Minsk airport has the lowest productivity based on PAX/RWA ratio.

3. Conclusions

1. The method of Data Envelopment Analysis proves to be most suitable for measuring the productivity of airports as complex systems.
2. The study of a range of 15 airports has disclosed that among 15 indicators of productivity (7 of those were initially identified by the author, 8 – by the experts following the first round of the Delphi survey), two indicators AIR/LAND and PAX/RWA were selected as the most important.
3. The DEA method has revealed that according to the two selected key indicators, in the range of 15 airports, Palanga and Stockholm airports have maximum marginal productivity based on AIR/LAND ratio. Copenhagen and Stockholm airports have maximum marginal productivity based on PAX/RWA ratio.

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