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# ANALYSIS OF THE TRANSPORT SERVICE OF AIRPORTS IN SELECTED EUROPEAN METROPOLITAN AREAS

**Summary**. The article presents the characteristics of transport systems in European metropolitan areas, providing a transport service of airports. The authors presented an analysis of statistical data and operating means of transport and compared the ways of servicing the airports. The process of transport service of an airport is influenced by the number of passengers handled, by the way, transport is organised in a given area and by infrastructural conditions. The article uses correlation analysis, regression models and linear correlation indices.

**Keywords:** metropolitan areas, transport service of an airport, public transport

## 1. INTRODUCTION

Transport is one of the most important and complex branches of a nation's economy [1-3]. As part of many interdependent systems, it offers the basis for their functionality and ensuring of proper handling in terms of the movement of goods and persons. In the complex transport processes occurring in many agglomeration centres, with public transport as one of its

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branches, that is generally accessible and also ensures the possibility of the distribution of people to fixed destinations, along specific transport lines.

The dynamically developing aviation market in Europe, and the rest of the world and the increasing number of passengers served determines the need to provide efficient transportation connections between urban centres and the airports [4-6]. In most metropolitan areas, they are realised by properly functioning public transport systems. The main aim of the transport service is to provide means by which airports may be reached quickly and competitively while being an integral part of the transport system in the region. Depending on the nature of the area and the conditions of the infrastructure, transport services are provided through different modes of transport, such as buses, trams, metro and railways. The article presents the analysis of the transport service of airports in selected metropolitan areas in Europe.

## 1. CHARACTERISTICS OF SELECTED EUROPEAN METROPOLITAN AREAS IN TERMS OF PUBLIC COLLECTIVE TRANSPORT SERVICES

The notion of the metropolis and the metropolitan area in literature is defined in various ways. There are many types of classification of metropolitan functions, in which the term should refer not to urban areas but to centres meeting the following criteria [4]:

- be relatively large (minimum 0.5-1.0 million inhabitants).
- have significant economic potential and highly developed tertiary service sector.
- be characterised by a high innovative potential (scientific and research and development units).
- perform metropolitan functions, that is, central functions of a high hierarchical order of at least national scope.
- play the role of a node in the system (networks) of communication, organisational and information links and be characterised by high accessibility at various spatial scales, as well as on an international scale.
- stimulate the development of a network economy and management model.

The basic functionality of each metropolitan area is providing well-organised and functional public transport system [7-10]. Depending on the circumstances, in most cases, the role of the public transport manager in the region is played by an organiser bringing together several dozens of different carriers. The most common means of transport are city buses running on several hundred lines, as well as regional and city railway, metro and trams. Table 1 shows selected metropolitan areas in Europe, taking into account the number of population and types of public transport modes in operation. Selected European metropolitan areas were adopted for the study according to the following criteria:

- metropolitan areas with the largest airports by number of passengers served.
- metropolitan areas where more airports operate, some of them have been adopted.
- only the operation of airports by public transport is taken into account.
- Polish airports are not included.

The purpose of collecting the data presented in Table 1 was to identify the relationships between the potential of a given area expressed by the population of residents and the transport offer for this area expressed by the number of lines of particular transport systems.

Tab. 1

Population and number of lines in selected metropolitan areas.

| Country | Metropolis | Population metropolitan areas | Mode of transportation - number of lines | | | | |
|---|---|---|---|---|---|---|---|
| | | | Bus | Train | Metro | Tram | Trolley |
| France | Paris | 10,950,000 | 1480 | 13 | 16 | 9 | |
| United Kingdom | London | 10,470,000 | 673 | 16 | 11 | | |
| Germany | Ruhr | 6,670,000 | 811 | 50 | 23 | 44 | 6 |
| Spain | Madrid | 6,310000 | 643 | 9 | 13 | 4 | |
| Italy | Milan | 5,280,000 | 297 | 12 | 4 | 17 | 4 |
| Spain | Barcelona | 4,790,000 | 683 | 11 | 11 | 6 | |
| Germany | Berlin | 4,105,000 | 872 | 62 | 10 | 47 | |
| Italy | Rome | 3,950,000 | 338 | 11 | 3 | 6 | 1 |
| Greece | Athens | 3,475,000 | 35 | 5 | 3 | 3 | 19 |
| Portugal | Lisbon | 2,700,000 | 146 | 9 | 4 | 5 | |
| United Kingdom | Manchester | 2,685,000 | 638 | 26 | | 7 | |
| Hungary | Budapest | 2,500,000 | 245 | 6 | 4 | 35 | 16 |
| Czech Republic | Prague | 2,300,000 | 310 | 36 | 3 | 30 | |
| Belgium | Brussels | 2,120,000 | 60 | 21 | 4 | 18 | |
| Germany | Hamburg | 2,105,000 | 613 | 28 | 8 | | |
| Germany | Munich | 2,025,000 | 301 | 24 | 8 | 13 | |
| Germany | Frankfurt | 1,950,000 | 334 | 55 | 9 | 9 | |
| Austria | Vienna | 1,785,000 | 127 | 4 | 5 | 29 | |
| Netherlands | Amsterdam | 1,650,000 | 957 | 22 | 4 | 17 | |
| Sweden | Stockholm | 1,565,000 | 456 | 3 | 7 | 9 | |
| Denmark | Copenhagen | 1,290,000 | 470 | 25 | 2 | | |
| Finland | Helsinki | 1,280,000 | 503 | 70 | 24 | 13 | |
| Ireland | Dublin | 1,158,000 | 122 | 17 | 1 | 31 | |
| Spain | Malaga | 725,000 | 80 | 2 | 2 | | |
| Switzerland | Zürich | 620,404 | 60 | 27 | | 15 | 6 |
| Spain | Palma de Mallorca | 550,000 | 103 | 3 | 2 | | |

Figure 1 shows the number of population in selected metropolitan areas. It is observed that metropolises located almost all over Europe were selected for the analysis. Moreover, the focus was on the most important urban centres of a given country. The analysis of the population of the inhabitants in the considered areas indicates that the largest of them are located in north-western Europe (Germany, France and, Great Britain). The metropolitan areas of southern and central-eastern Europe are less populated

Figure 2 shows the dependence of the population and the means of transport lines in selected metropolitan areas. Figures 3 and 4 present the number of lines and the share of the mode of transportation in selected metropolitan areas.

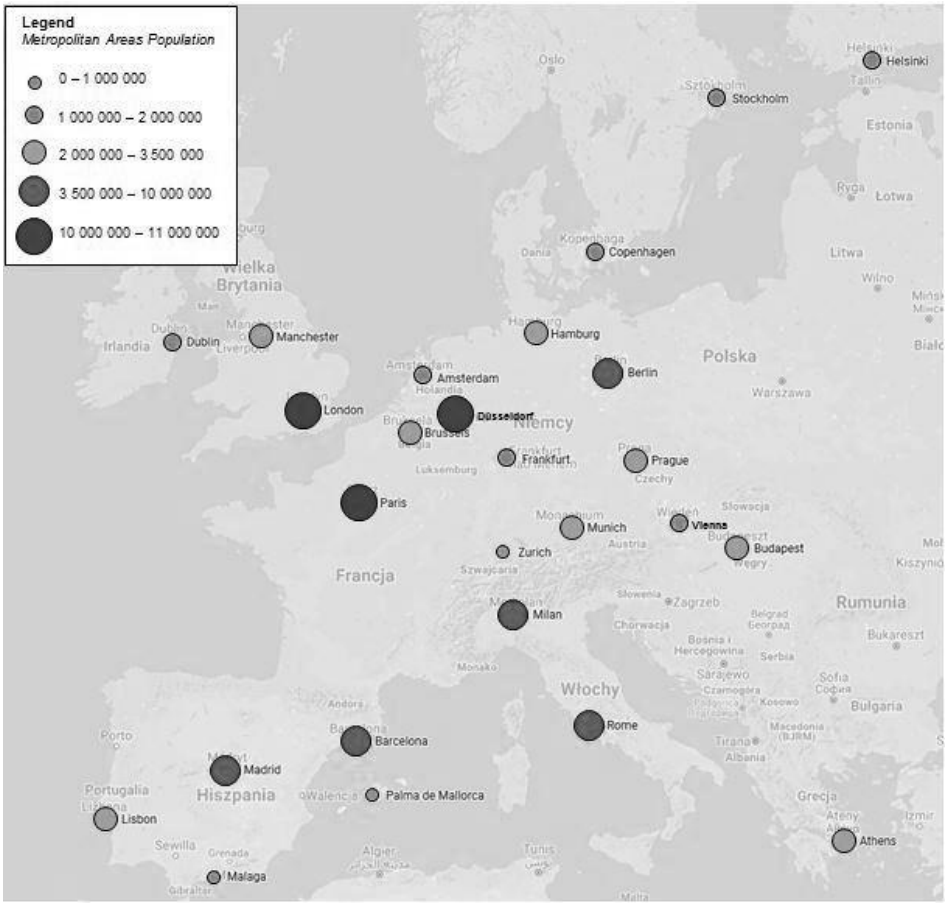


Fig. 1. Number of the population in selected metropolitan areas

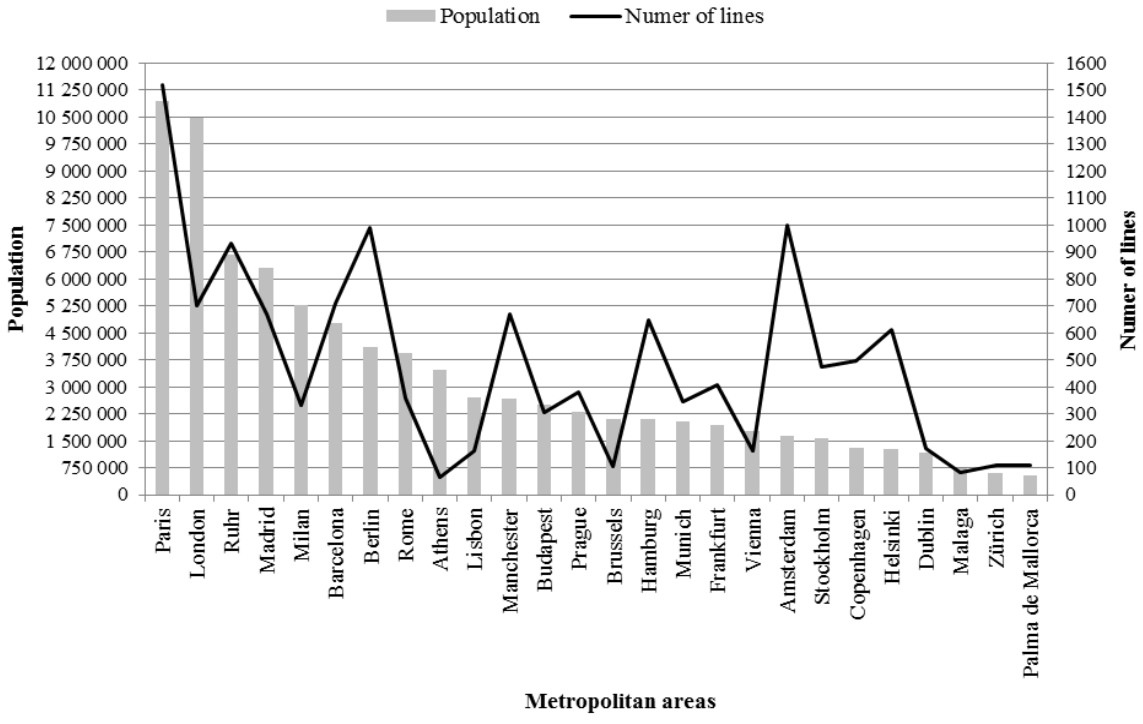


Fig. 2. Population and means of transport lines in selected metropolitan areas

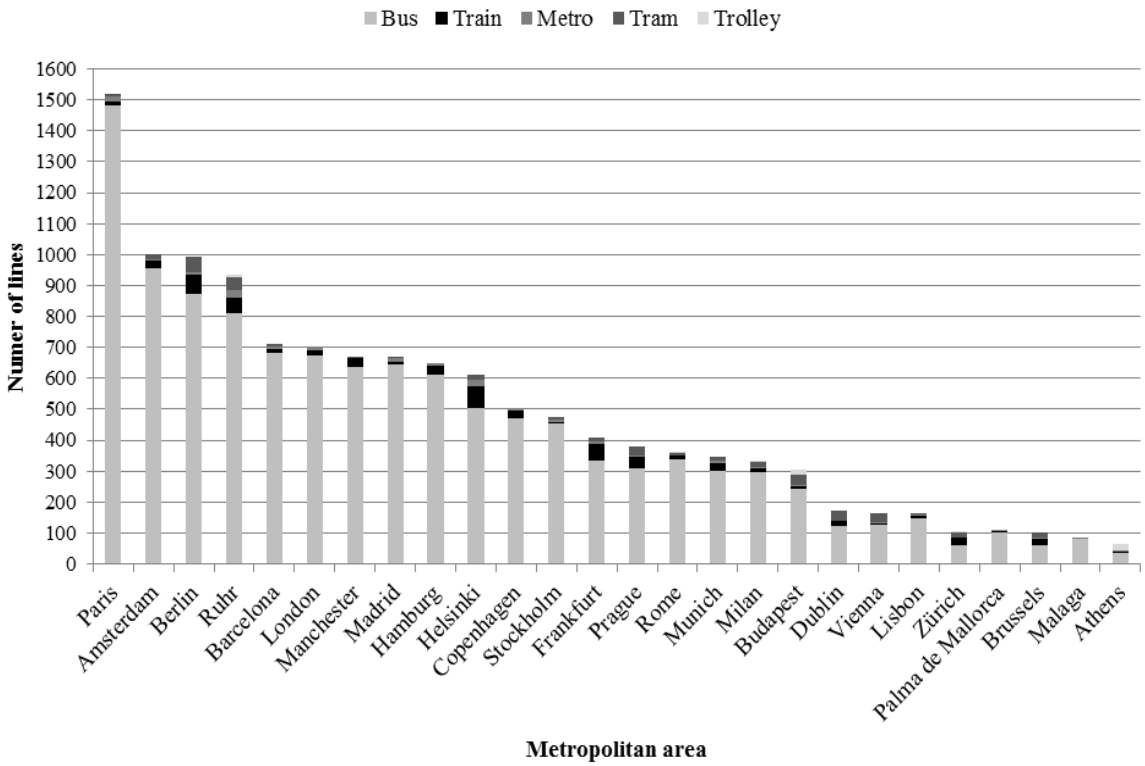


Fig. 3. Mode of transportation and number of lines in selected metropolitan areas

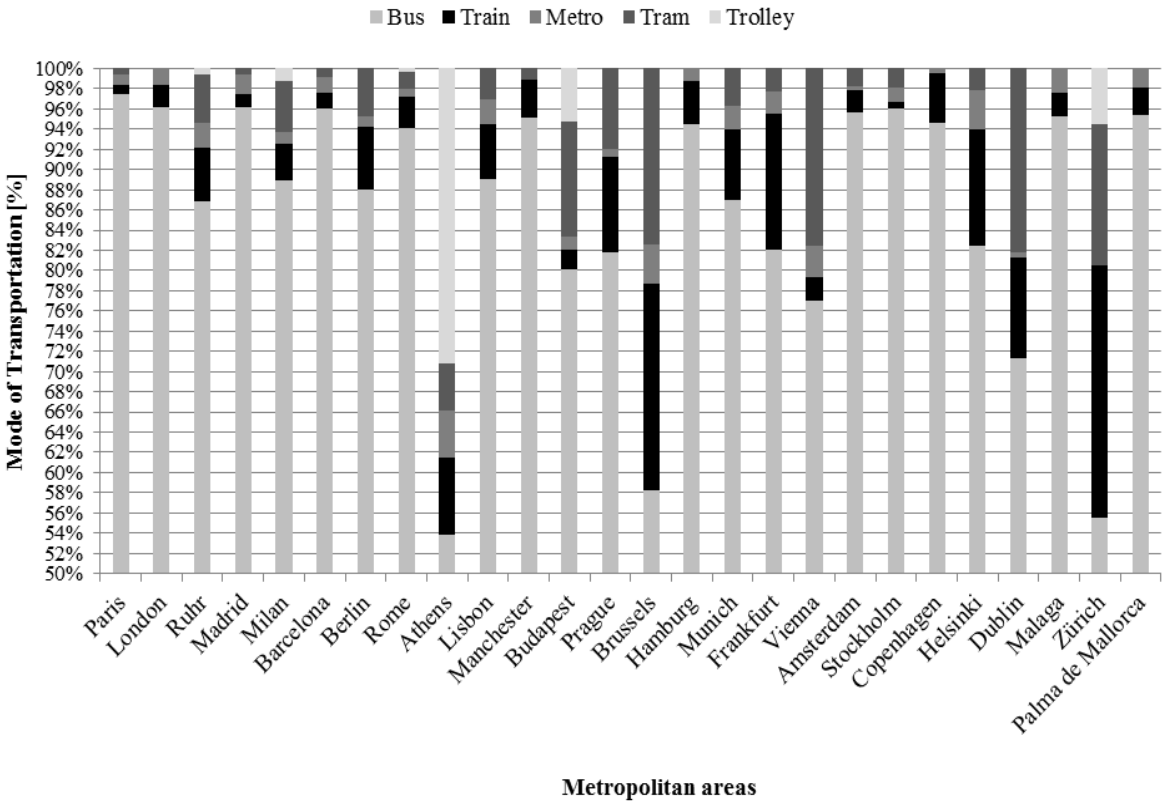


Fig. 4. Share of mode of transportation in selected metropolitan areas

Presentation of data summarised in Table 1 and Figures 2 to 4 gives a full picture of the transport offers in all metropolises. Considering the data presented in Figure 1, it is not possible to clearly state what the relationship between the inhabitant population and the number of public transport lines.

The largest number of public transport lines exist in Paris. This metropolis is also characterised with the largest population. About 1,000 lines serve Berlin and Amsterdam. At the same time, the second metropolis is characterised with more than half a smaller population. The smallest number of public transport lines was recorded in Athens, Brussels and Malaga. However, the population of Athens is about 1,000,000 more than Brussels and over 2,500,000 more than Malaga.

The analysis of the data presented in Figure 2 indicates that buses are the mode of transport most often used in metropolitan transport services. This is obviously natural because this means of transport is characterised by the greatest accessibility. However, there are metropolises, where the share of other transport means other than buses are high. This is particularly true for Athens, Brussels and Zurich. In the first metropolis, the share in question is about 46%, of which the trolleybuses are the most. In Zurich, it is around 44% of which the largest number of public transport lines offers a train, similar to Brussels, where the number of railway and tram lines are at a similar level.

## 2. THE TRANSPORT SERVICE OF AIRPORTS IN SELECTED EUROPEAN METROPOLITAN AREAS

The airports are the integral parts of most European metropolitan areas. An important element of their proper function is the adaptation of transport services with the main urban centres of the metropolis.

Figure 5 shows the number of passengers served in 2017 in selected European airports.

Table 2 shows selected metropolitan areas with the airports serving them, the number of passengers served in 2017 and the modes of transport enabling the connection. In the table the following abbreviations are used for means of transport: B – Bus, T – Train, M – Metro. Tram connections are not included as only two airports have this mode of transportation.

Tab. 2

Selected European airports with a mode of public transport connections.

| Country | Metropolis | Airport IATA Code | PAX 2017 | Mode of transportation | | |
|---|---|---|---|---|---|---|
| | | | | B | T | M |
| United Kingdom | London | LHR | 78 013 771 | | ✓ | ✓ |
| France | Paris | CDG | 69 473 157 | | ✓ | |
| Netherlands | Amsterdam | AMS | 68 515 425 | ✓ | ✓ | |
| Germany | Frankfurt | FRA | 64 500 386 | ✓ | ✓ | |
| Spain | Madrid | MAD | 53 388 044 | ✓ | ✓ | ✓ |
| Spain | Barcelona | BCN | 47 262 826 | | ✓ | ✓ |
| Germany | Munich | MUC | 44 577 241 | | ✓ | |
| Italy | Rome | FCO | 40 968 756 | | ✓ | |
| Ireland | Dublin | DUB | 29 582 468 | ✓ | | |
| Switzerland | Zürich | ZRH | 29 345 153 | | ✓ | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Denmark | Copenhagen | CPH | 29 134 235 | ✓ | ✓ | ✓ |
| Spain | Palma de Mallorca | PMI | 27 968 521 | ✓ | | |
| United Kingdom | Manchester | MAN | 27 901 040 | ✓ | ✓ | |
| Sweden | Stockholm | ARN | 26 683 732 | | ✓ | |
| Portugal | Lisbon | LIS | 26 663 385 | ✓ | | ✓ |
| Belgium | Brussels | BRU | 24 751 493 | ✓ | ✓ | |
| Germany | Ruhr | DUS | 24 640 564 | ✓ | ✓ | |
| Austria | Vienna | VIE | 24 392 705 | | ✓ | |
| Italy | Milan | MXP | 22 160 090 | | ✓ | |
| Greece | Athens | ATH | 21 705 312 | ✓ | ✓ | ✓ |
| Germany | Berlin | TXL | 20 459 995 | ✓ | | |
| Finland | Helsinki | HEL | 18 892 386 | ✓ | ✓ | |
| Spain | Malaga | AGP | 18 628 876 | ✓ | ✓ | |
| Germany | Hamburg | HAM | 17 616 455 | ✓ | | |
| Czech Republic | Prague | PRG | 15 415 001 | ✓ | | |
| Hungary | Budapest | BUD | 13 097 239 | ✓ | | |

Fig. 5. Number of passengers in selected European airports

The train is used 19 times in the transport service presented in Table 2 of airports, bus 17 times and metro - 6. Thirteen airports are served by one means of transport, including 7 using railways. Thirteen airports use at least 2 means of transport. In this second set, 10 airports are served by 2 means of transport (mostly by train and bus). Three airports use bus, train and metro for transport.

## 3. THE ANALYSIS OF CORRELATION

In order to analyse the transport service of airports in selected European metropolitan areas, the Pearson correlation coefficient method was applied. The coefficient allows to determining the level of linear dependence between random variables. The application of the method allowed to determine the relationships between the number of passengers served at selected airports and the population of selected European metropolitan areas. Next, the relationship between the number of passengers served at selected airports and the number of journeys of particular means of transport serving these airports were determined. Figure 6 shows the relationship between the number of passengers and the population of selected European metropolitan areas.

Figures 7, 8 and 9 show the relationship between the number of passengers and the different modes of transport serving airports.

Figure 6 shows the relationship between the number of inhabitants and the number of passengers served at the airports. It may be seen that the larger the number of inhabitants, the more passengers the airports have to serve. However, the correlation between these variables is not very strong. Therefore, there are other factors affecting the number of passengers served. It seems that it may be terminal capacity, the nature of the area in which the airport operates (economic, tourist) and others. The study of these dependencies will constitute the basis for future research.

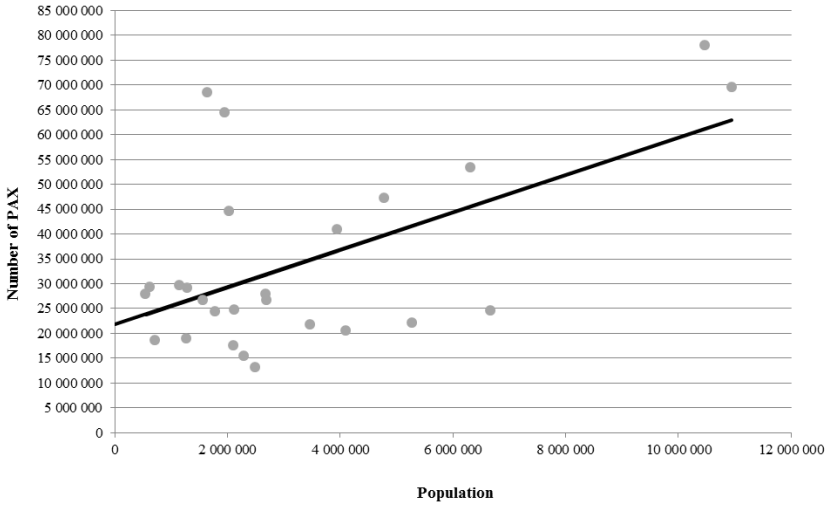


Fig. 6. Relationship between the number of passengers and population in selected metropolitan areas

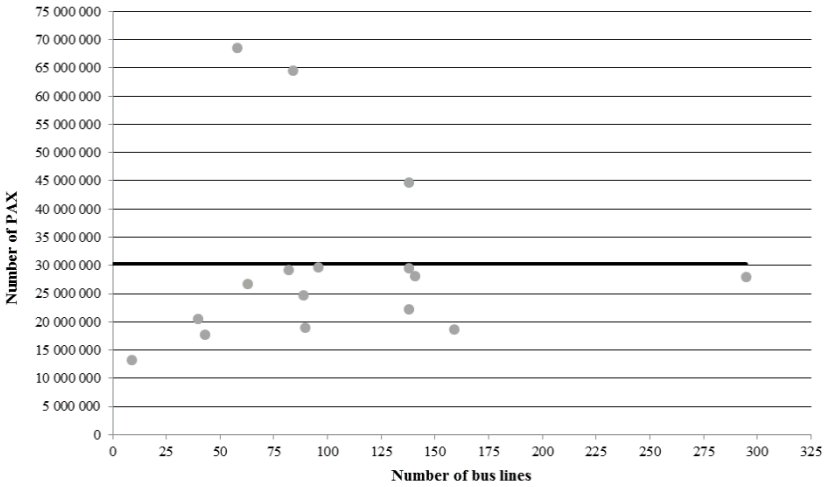


Fig. 7. Relationship between the number of passengers and number of bus lines

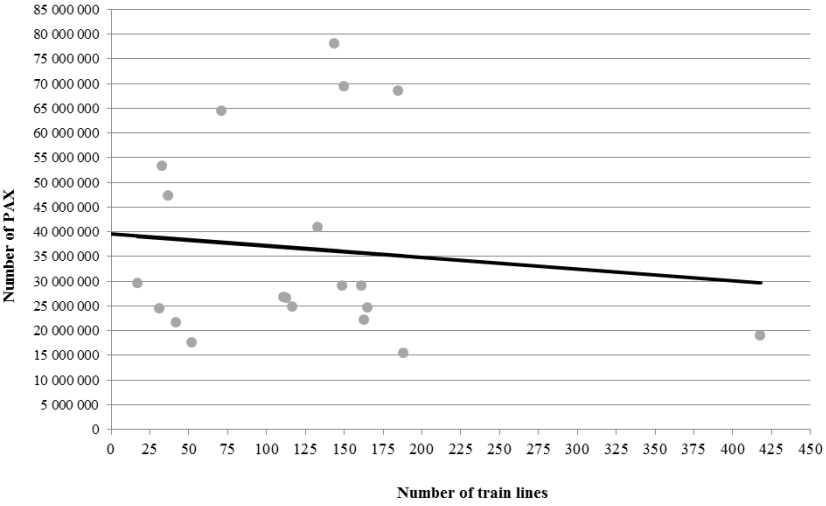


Fig. 8. Relationship between the number of passengers and number of train lines

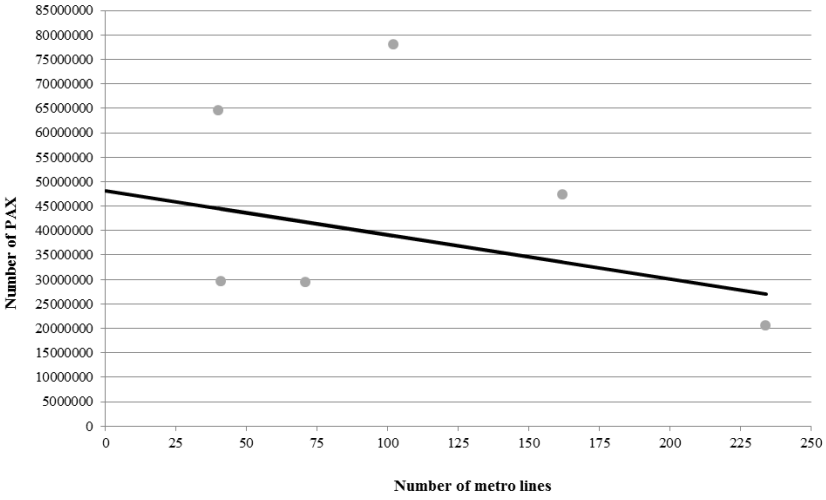


Fig. 9. Relationship between the number of passengers and number of metro lines

The data presented in Figures 7, 8 and 9 are the confirmation of the earlier thesis on the difficulty in determining the nature of the relationship between the population of residents and the number of public transport line. The analysis of the relationships showed the following dependencies:

- correlation between PAX and population ($R^2$ = 0,560) is moderate and positive.
- correlation between PAX and bus lines ($R^2$ = 0,001) is weak and positive.
- correlation between PAX and train lines ($R^2$ = 0,106) is weak and negative.
- correlation between PAX and metro lines ($R^2$ = 0,436) is moderate and negative.

## 4. CONCLUSIONS

The article presents the results of the analysis regarding the transport service of selected airports in Europe. The results of the analysis indicate that it is different and this is shown in Table 2. It is also difficult to find a relationship between the number of passengers served and the number or type of transport means used to operate airports.

The bus offers the richest transport offer in terms of the number of lines serving the given airport. In each of the analysed airports, at least 50% of the courses are served by this means of transport.

The analysis of the relationship between the number of passengers served and the number of lines of a given means of transport indicates that these variables are not correlated. This is confirmed by Figures 7, 8 and 9. Therefore, the selection of the transport means to operate in an airport depends on factors other than the number of passengers served. It seems that they may be spatial management (the distance of the airport from the centre), available transport resources in a given area and others. This probe will be the area for further research.

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