Mapping the regional science performance. Evidence from Poland

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Abstract

The aim of the paper is use of some scientometric indicators in order to evaluate regional science performance in Poland. The analysis is based on overall publication output in international peer reviewed journals covered in Web of Science database in the period 2001-2006. The value added of the paper is three fold. Firstly analysis is done on the subregional level. That gives the opportunity to conduct detailed analysis of the science potential of particular science center in Poland. Secondly, the scientific specialization of the Polish regions is described using the prepared database. Thirdly, the application of the network to examination of papers written in co-authorship enables to depict different cooperation patterns.

1. Introduction

Poland likewise most of other countries is characterized by the relatively high regional diversity in both economic and social terms. The scientific activity has as well a substantial regional dimension. There are many examples of the territorial concentration of inputs and outputs related to the production of knowledge, which is uneven spatially distributed. One can as well observe high durability of the processes in this respect. However, some new aspects which have occurred recently shed a new light on these problems. First of all, the scientific progress is universally seen as one of the most important economic factors, especially when correlation between the scientific knowledge and the technological innovation is very strong. Additionally, support of the science is nowadays more frequently treated as an instrument of the regional development. Thus, the knowledge about a regional or even local scientific potential has also a growing practical importance. The diagnosis on the regional level allows to formulate appropriate policy aims and therefore facilitate to select measured for their achievement.

The aim of the presented paper is to use of some scientometric indicators in order to evaluate the regional science performance in Poland. The science potential on the regional level is usually measure by using broadly/widely accepted indicators like for example the number of R&D staff or the level of R&D spending. The paper is focused on adding to this set of measures those rooted in the scientometrics. Research on science development based on quantitative analysis of texts is already well established, with well developed methods and tools [1]. Extensive research in this area is

conducted both in foreign research centres and in Poland. The research, however, very seldom pertains to the regional level, or the level of scientific centres. The data for this type of analyses come mostly from electronic databases, containing bibliographical descriptions of publications and indexes of scientific citations. Among numerous databases of this type the one with the broadest scope is the Web of Science (WoS) database, most frequently used for bibliometric analyses.

The analysis presented in the paper is based on the overall publication output in international peer reviewed journals, covered in the Web of Science database, during the period 2001-2006. Authors present their own research approach using the database, comprising of 72 817 articles with at least one Polish affiliation. The analysis was conducted on a subregional level (NUTS 3). This level seems to be the most appropriate in this case, since it adequately reflects the situation in scientific centers of Poland, i.e. in cities or agglomerations where scientific activity is concentrated. For each subregion and city centre the number of articles was calculated. Moreover, the patterns of national and international cooperation, as well as science specialization for each particular subregion, were determined and illustrated.

2. *Regional science performance*

The science performance in Poland is concentrated in big agglomerations, likewise in other countries. That concentration can be proved by using different kind of measures, e.g. the number of researchers or the expenditures on R&D. The analysis of the publication data shows the similar patterns. First of all there is a noticeable domination of the Polish capital subregion where 41% of the total expenditures on research and development as well as 27% of research and development staff are located. Also the biggest share of the articles with at least one Polish affiliation is attributed to the Warsaw capital region (27%). Secondly apart of Warsaw subregions there are seven outstanding subregions in terms of three measures mentioned above, all of them are closely linked to the big Polish cities, i.e.: krakowsko-tarnowski (15%), wrocławski (10%), poznanski (9%), łodzki (7%) and lubelski (5%) or group of cities, i.e.: centralny slaski (6%) and gdanski (6%).

Fig. 1: The number of publications in Web of Science in 2001-2006 (39 subregions).
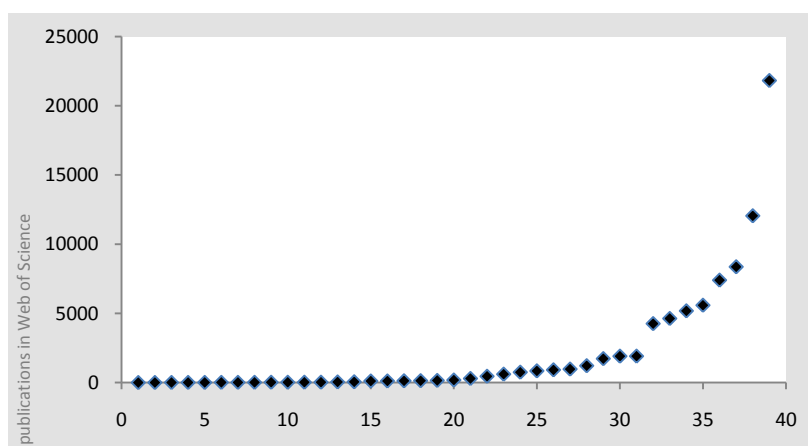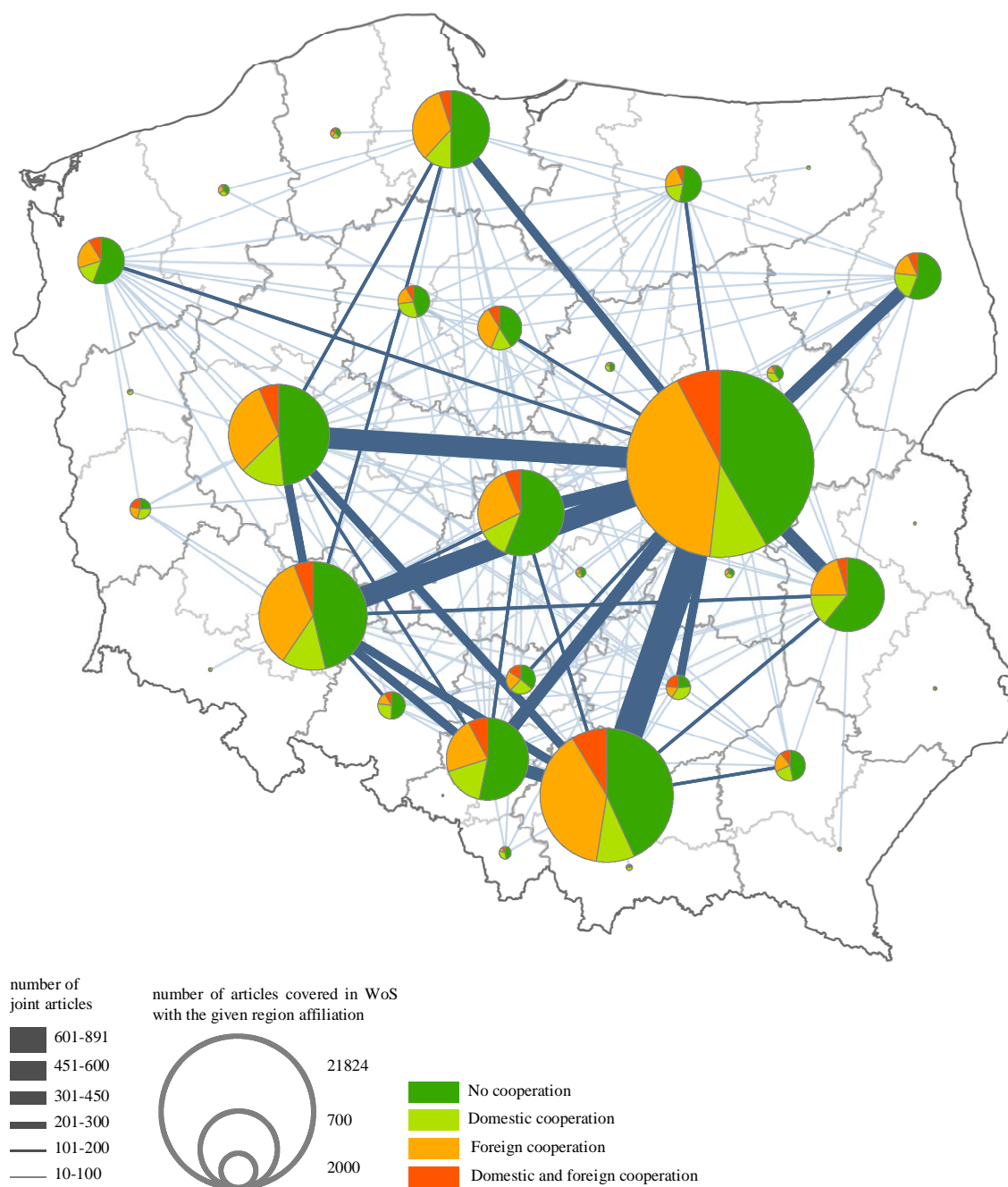

Source: prepared by the authors on the basis of data from Web of Science.

Strong concentration in eight subregions reflects great diversification of the polish territory in terms of innovativeness and shows relative weakness of the remaining regions. Endogenic potential of Poland is located in the few locations. Moreover there is substantial distance between Warsaw subregion and the group of seven subregions next on the list (fig. 1). Thus one can say that

metropolitan region of Warsaw constitute the separate category within the Polish innovation system. That could lead to speculation that the diversification of the polish subregions is not only quantitative but also qualitative character/nature. It seems that the weakness of the remaining subregions (31 out of 39, without Warsaw and 7 "second league" regions) substantiate that thesis.

There is also a strong correlation between the number of articles and the number of researchers as well as the population numbers (fig. 2). In the end, 8 most populous and most urbanized subregions are responsible for 88% of overall Polish publication output. Analysis of the broader time data series shows that the spatial pattern depicted above is characterized by the high durability. Namely, there are no considerable changes observed in the period 2000-2006.

Fig. 2: The number of publications in Web of Science in 2001-2006 (39 subregions).

number of
joint articles

601-891
451-600
301-450
201-300
101-200
10-100

number of articles covered in WoS
with the given region affiliation

21824

700

2000

■ No cooperation
■ Domestic cooperation
■ Foreign cooperation
■ Domestic and foreign cooperation

Source: prepared by the authors on the basis of data from Web of Science.

3. *Scientific cooperation*

As many publication shows cooperation in science is a very common and getting stronger phenomenon. It is the result of the growing science specialization from the one site, and of the need of interdysciplinarity from the other. Some research couldn't be conduct without work of many scientists from different institutions and countries. Hence there is a vast need of scientific and reliable measurement of the cooperation patterns. Analysis of the bibliographic data gives great opportunities in that respect and makes the description of the cooperation patterns of regions feasible.

To analise the territorial dimension of the cooperation among different institutions measured by the number of joint publications all the publications were categorized into four separate groups:

- Publications written with no cooperation- articles affiliated to institution/s located in the same Polish subregion.

- Publications written in domestic cooperation- articles affiliated to at least two institutions located in different Polish subregions.

- Publications written in foreign cooperation- articles affiliated to at least one Polish institution located in Polish subregion and to at least one located abroad.

- Publications written in domestic and foreign cooperation- articles affiliated to at least two Polish institutions located in two different Polish subregions and to at least one located abroad.

While the publications from the first category "no cooperation" represent more than a half of the data set from the years 2001-2006, articles written in domestic cooperation amount to 7% only. Quite a big share in the total number of articles has those publications with at least one foreign partner, and what is interesting it is the measure which the most considerably diversify polish territory (fig. 2). The share of the category "foreign cooperation" correlates with the number of articles affiliated in the particular region thus it is the highest in the warszawski, krakowsko-tarnowski, torunsko-wloclawskim, wroclawski, gdanski and poznanski subregion, whereas subregions with lower publication performance represent lover foreign cooperation.

The basic conclusion drawn from the analysis of spatial linkages between Polish subregions is that, the core node in the collaboration network is Warsaw. Institutions located in the Polish capital city are main partners for other situated in the remaining parts of the country (fig. 2). Strong relations are observed also among institutions located in krakowsko-tarnowski, centralny slaski, wroclawski and poznanski subregions.

Each of the subregion can be characterized also in terms of the direction of the foreign cooperation. The most important partner for most of the entities was Germany or The United States. Only few subregion cooperate the most intensively with partners from other countries, e.g. France or Ukraine. Territorial pattern of the described spatial specialization is very interesting, because subregions which cooperate predominantly with Germany are situated in the south-west part of the country while those which collaborate with the USA are located in the north-east part of Poland.

4. Regional specialization

The detailed categorization of publications adopted in the Web of Science provides also the possibility to describe fields of the specialization for each particular subregion. Both, the "narrow science fields" approach (i.e. computer science; biochemistry and molecular biology; engineering, electrical and electronic) as well as the "wide branches of science" approach (science, engineering, medicine & health sciences and agriculture) were used in order to investigate the subregional specialization in Poland.

First approach utilized the 217 science categories which were identified in the data set. One should remember though that each publication could be classified to more than one science category. The results for chosen science fields are described in the next section of the article.

Second approach was based on the five wide branches of science aggregated by using the OECD classification of science fields. More than a half of total number of publications with polish affiliation has been putted into the "science" category, 20% into "engineering" and 16% to "health and Medicine". Definitely lower share has the "Agriculture" category (5%), or publications from social sciences, humanities and art (1% altogether). The described structure of the dataset is related to the specificity of the Web of Science data base oriented towards science, medical and technical sciences. The data set used for the study does not reflect though the real structure of the Polish publication's output. Nevertheless it is a good starting point for the comparisons of the publication performance of regions in the given science field and it can be use to describe the field specialization of the region (map 2).
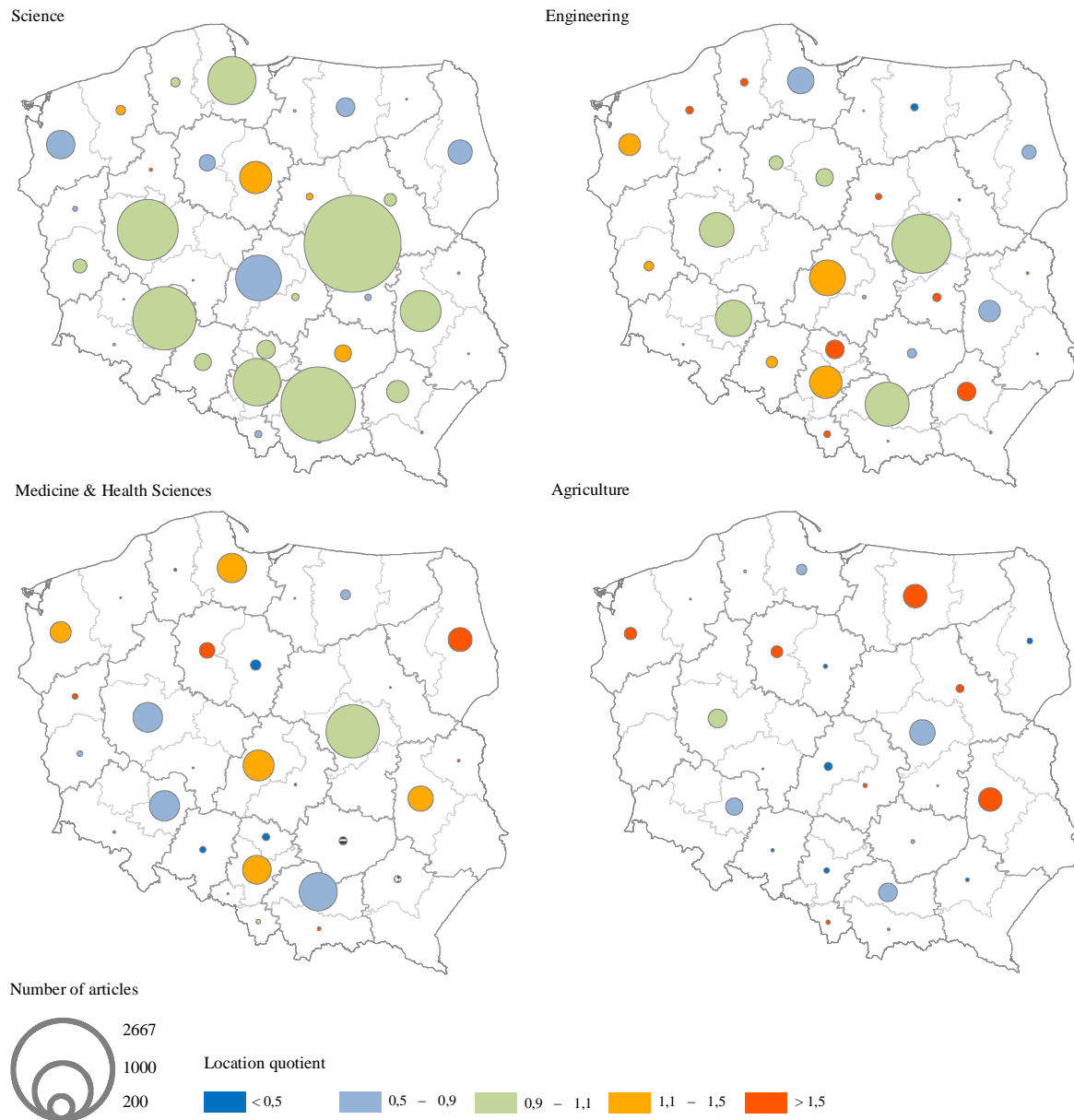
The analysis was based on the Location Quotient method. Location Quotient is an indicator that shows the relative position of the territorial unit in the given country. For the particular purpose of this study employment data usually used to construct the LQ, was replaced by the bibliometric measures:

$$LQ = (E_{ir}/E_r)/(E_{in}/E_n)$$

where: E_{ir} – the number of articles in field i in region r, E_r – the total number of articles in the r region, E_{in} – the number of articles in the field i in all country, E_n – the total number of articles in the country. LQ>1 means regional specialization in the given science field (see Capello [2], s. 117).

The results of the regional specialization analysis for the wide science branches are shown in the fig. 3. The conclusions drawn from the maps are twofold. Firstly, it is obvious that the more publications are affiliated in the given subregion, the broader scope of specialization in different science fields is observed. Secondly, it is possible to describe territorial pattern of specialization for each of the broad science branch. The subregions with the high level of the LQ indicator combined with relatively high number of the publications in engineering and the technical sciences are clustered and concentrated in the south-central part of the country, while subregions with agricultural specialization are concentrated in the north-eastern Poland. It is worth noticing that science specialization correlates very well with the general profiles of these regions. Science oriented publications are typical for three subregions only: torunsko-wloclawski, koszalinski and swietokrzyski while territories with medical specialization are evenly distributed in the Polish space.

Fig. 3: Specialisation of Polish subregions in wide science fields in 2006.

Science

Engineering

Medicine & Health Sciences

Agriculture

Number of articles

2667

1000

200

Location quotient

< 0,5   0,5 − 0,9   0,9 − 1,1   1,1 − 1,5   > 1,5

Source: prepared by the authors on the basis of data from Web of Science.

5. Examples of narrow science fields on a city level

The bibliometric data analysis is a good tool for cooperation study on the city level as well. The 40 centers with the number of publications more than 80 articles were chosen from the original data set. They differ widely in character and size: from small Bytom in the Silesia region (82 publication) to the capital of Poland, Warsaw (20962 articles). Majority of centers are cities and as expected the highest publication output is related to the regional capitals, while smallest cities in the group are localized in the metropolitan areas of Warsaw or Krakow (fig 4).

Basic observation is that the publication output is related to the size of the centre measured by the population. There are though some exceptions of small cities with high performance due generally to the unique and excellent research institutes localized there (Otwock, Pulawy).

Moreover, the share of publications written in international cooperation is absolutely higher in the big city centers. This led us to the conclusion that achievement of the high number of the articles could be unfeasible without an appropriate level of teamwork mainly with foreign partners. The possible explanation of that phenomenon is threefold. Firstly, some of science fields are characterized by higher than others need or necessity of international cooperation which seems essential for the research results, e.g. astronomies (Torun), nuclear physics (Otwock). Secondly, an important factor seems to be the localization in the metropolitan area (Otwock, Sopot, Blonie, Lomianki). And thirdly, in the case of small institutions international cooperation could be the only opportunity for publication in the peer-reviewed journals (Slupsk, Koszalin).

As it was mentioned before science fields vary greatly in cooperation patterns. For the article needs the analysis of three different science fields related to the Journal Citation Report's thematic classification has been done. These are as follows: mathematics, material science as well as biology and biochemistry. Previously described relation between the city size, the publication performance and the level of cooperation is different for each case. It is definitely more distinct in the biology and biochemistry case than in the mathematics. In the material science case the distance between Lodz (second Polish city in terms of population) and other cities regarding share of foreign cooperation is striking.
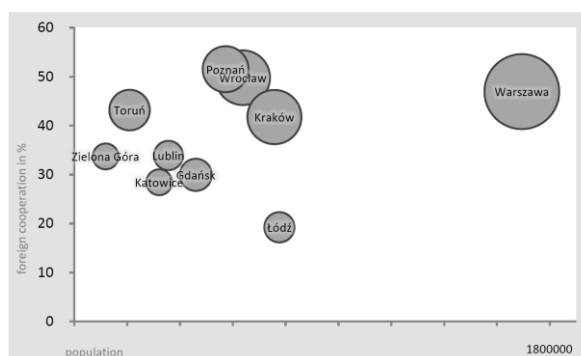
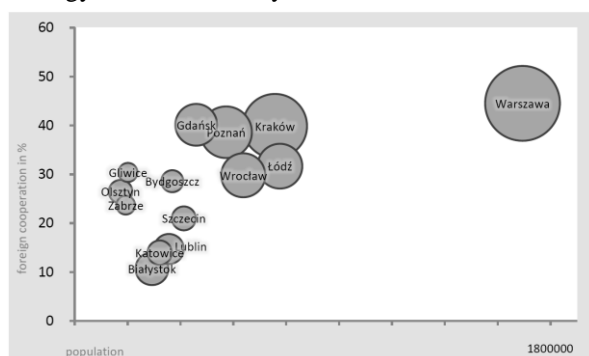Fig. 4: Publications in Polish centers in the years 2001-2006
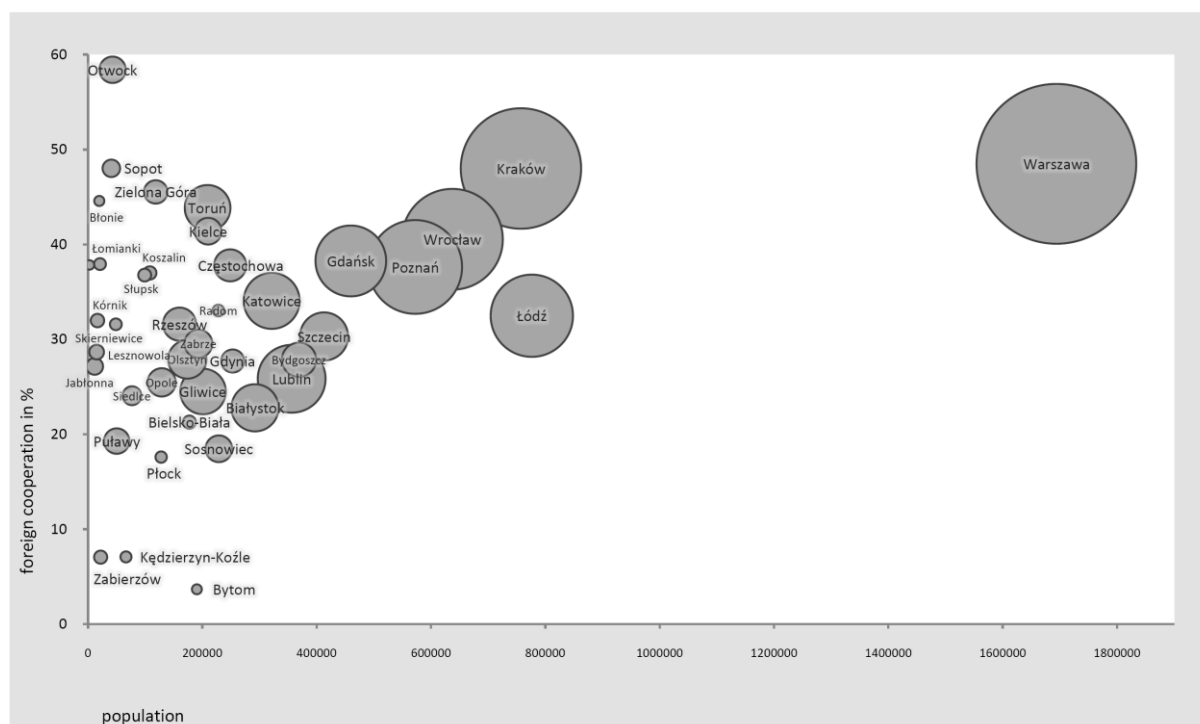
Material science
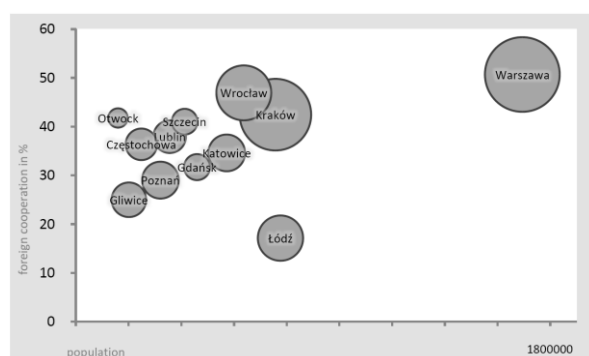
Mathematics

Biology and biochemistry

Source: prepared by the authors on the basis of data from Web of Science.

6. Conclusions

It should be emphasized that bibliometric analyses provide very significant opportunity for studying the spatial aspects of scientific activity. Such analyses are most frequently conducted on the national level. Operating on the level of regions or even individual centres, however, also becomes more and more frequent (see e.g. Matthiessen, Schwarz, Find [3], Observatoire des Sciences et des Techniques [4], Olechnicka, Ploszaj [5]). The lower level of analysis seems to have a large potential, which so far has not been fully utilized. It also has a considerable practical importance, especially in the context of the regional innovations systems theory. The diagnosis of the regional scientific capacity, its differentiation, various areas of specialization and the scope and directions of cooperation (in this article briefly presented on the example of Poland) may significantly contribute to creation of more effective regional scientific policies. Consequently, the spatial bibliometric research acquires markedly practical characteristics.

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