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Maciej TURAŁA*

INNOVATION-BASED POTENTIAL FOR DEVELOPMENT OF CITIES IN POLAND

POTENCJAŁ INNOWACYJNY ROZWOJU MIAST W POLSCE

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ABSTRACT: The article aims to put forward a method for measuring the innovation potential of cities as one of the main drivers – alongside education and culture – of their development potential (Orankiewicz, Turała 2019). The discussion which is carried out in the paper starts with the concept of territorial capital put forward by Camagni and Capello (2013) and refers to other approaches to measuring the innovation potential of cities (Marszał 2012; Siłka 2018). The main assumptions behind the method of measurement are briefly described in the second part of the article – the proposed measurement of innovation potential reflects four factors: (1) the capacity to generate knowledge and innovative solutions; (2) the capacity to disseminate research results; (3) the capacity to bridge the gap between academia and economic activity or, in other words, the capacity to commercialise research outcomes and (4) the robustness of economic activity in the most innovative sectors. Data on the above factors of innovation potential were collected for all urban communes in Poland (306 cities) for the period between 2013 and 2016. A set of rankings of Polish cities based on their innovation potential between 2013 and 2016 is then presented – the third part of the article discusses the differentiation of innovation potentials of cities by region as well as in different classes in terms of city size. The final part of the article concentrates on the significance of various drivers of the innovation potential of cities.

KEY WORDS: cities, development potential, knowledge, innovation

ABSTRAKT: Za podstawowy cel artykułu przyjęto przedstawienie propozycji metody pomiaru potencjału innowacyjnego miast. Przyjmuje się, że potencjał innowacyjny jest jedną z podstawowych determinant rozwoju miast – obok kultury i edukacji oraz kształcenia na poziomie uniwersyteckim (por. Orankiewicz & Turała 2019). Artykuł omawia w pierwszej kolejności koncepcję kapitału terytorialnego sformułowaną przez Camagni'ego i Capello (2013) i odnosi się innych podejść do pomiaru opartego na innowacyjności potencjału rozwojowego miast (Marszał 2012; Siłka 2018). Założenia metody pomiaru zostały zwięźle opisane w drugiej części artykułu - proponowana metoda uwzględnia cztery czynniki: (1) potencjał na rzecz generowania wiedzy oraz innowacyjnych rozwiązań; (2) potencjał na rzecz upowszechniania wyników prowadzonych badań; (3) potencjał dla łączenia sfery akademickiej z biznesem poprzez m. in. współtworzenie innowacyjnych rozwiązań w przedsiębiorstwach i komercjalizację wyników badań naukowych oraz (4) potencjał dla prowadzenia aktywności gospodarczej w sektorach uznanych za innowacyjne. Na potrzeby analizy zgromadzono dane dla wszystkich gmin miejskich w Polsce w okresie 2013–2016 (łącznie dla 306 miast). Na podstawie

* Lodz University, Faculty of Management, Department of City and Regional Management, e-mail: maciej.turala@uni.lodz.pl, ORCID: https://orcid.org/0000-0003-1054-8048

zgromadzonych danych opracowano rankingi miast w oparciu o uśrednioną wartość wskaźnika potencjału innowacyjnego dla lat 2013 – 2016. W trzeciej części artykułu omówiono m. in. zróżnicowanie potencjałów innowacyjnych miast w poszczególnych województwach jak również w podziale na różne klasy wielkości. W ostatniej części artykułu omówione zostały również wyniki analizy istotności poszczególnych czynników kształtujących potencjał innowacyjny miast.

SŁOWA KLUCZOWE: miasta, potencjał rozwojowy, wiedza, innowacje

1. Introduction

The concept of territorial capital is the starting point for this article. Camagni and Capello (2013: 1387) described 'territory' as a system which is composed of:

1. localised externalities of pecuniary as well as technological nature;
2. spatially localised actions and traditions which are related to production activities and the skills and know-how required for these activities;
3. spatially localised relationships and dependencies of socio-psychological or, indeed, political nature, which increase the productivity of locally available production factors;
4. locally existing values and other cultural elements which determine local identity and serve as development potential either on their own or as catalysts for more efficient usage of other resources;
5. the system of principles and practices which the local governance model consists of.

Based on this definition of 'territory', the same authors (Camagni, Capello 2013: 1387-1390) defined the concept of 'territorial capital', using the criteria of rivalry and materiality. The first of these criteria may be linked to rivalry and excludability which are used in the theory of public finance (Stiglitz 2004: 150-151) in order to differentiate between public goods and private goods. Camagni and Capello used the criterion of rivalry to differentiate between public goods, private goods and mixed goods, also referred to as club goods or imperfect public goods. The second of these criteria (materiality) is used in order to differentiate between material goods, immaterial goods and mixed goods.

Similarly as some other papers (Camagni, Capello 2013; Fratesi, Perucca 2018; Russ, Bansal, Parrillo 2015), this article concentrates solely on a selected fragment of broadly defined territorial capital, the innovation-based potential for development of cities which will be referred to as 'innovation potential'.

The ability to generate various types of knowledge and to disseminate it, and ensure its absorption by business entities and other types of organisations is one of the more frequently raised aspects of innovativeness (Knight 1995). The role played by innovations in the development of cities requires specific attention – hence it became the main area of interest for the author of this article.

Marszał (2012) defined innovativeness of cities as the capacity to implement new solutions, relative to the currently used ones, in various spheres of socio-economic activities. A similar approach to innovativeness of cities is shown by Montgomery

(2007: 29) who emphasises that the development may occur in cities through a number of possible actions, such as implementation of new production processes or new services, creation of new economic sectors and professions, leading to a new division of labour. It needs to be emphasised that cities are places where innovative processes are concentrated – mostly due to a high concentration of highly skilled people and numerous economic entities. Multiple opportunities for networking and interaction between these economic actors result in a particularly fast pace of dissemination of innovative solutions (Glaeser 2011: 8).

The role which cities play in the process of generating and disseminating innovations is not always of the same nature. The social and economic conditions of various cities have a lasting impact on the perspectives for the inhabitants as well as on the cities' ability to create and maintain an environment which supports innovativeness. In other words, different cities have a different capacity to attract and keep highly qualified employees, to create institutions and to support economic entities, including those which base their activity on innovations (Katz, Bradley 2013). Such differences are visible in particular between the metropolitan cities and smaller cities, a circumstance which comes about as a result of the fact that various types of innovations – and related activities – require a different scale and scope of interactions and a different density of the network which exists between local economic actors (Gertler, Wolfe 2016: 11).

Taking into account the above considerations, the main aim of the article was formulated as putting forward a method for measuring the innovation potential of cities. It is assumed that the innovation potential is one of the main drivers – alongside education and culture – of the cities' development potential (Orankiewicz, Turała 2019). The main assumptions behind the method of measurement are briefly described in the second part of the article. A set of rankings of Polish cities based on their innovation potential between 2013 and 2016 is then presented – the third part of the article discusses the differentiation of innovation potentials of cities by region as well as in different classes in terms of city size. The final part of the article concentrates on the significance of various drivers of the innovation potential of cities.

2. Innovation potential of cities – method of measurement

One of the most recent approaches to measurements of the innovation potential of cities was put forward by Siłka (2018: 111-112), whose method is based on 21 partial indicators which relate to the scientific sector, the research and development sector, enterprises and support institutions, industrial enterprises and the structure of enterprises in terms of R&D intensity.

The method which is discussed in this article is also based on indicators which relate to the scientific as well as business sectors, although it uses far fewer indicators. The synthetic measure of the innovation potential which is put forward in this article employs 8 indicators which represent four factors (drivers) of innovation potential. These are: (1) potential of higher education institutions in various cities to conduct award-winning

research and generate knowledge and innovative solutions; (2) potential for disseminating research results combined with creating cooperation networks and relational capital; (3) potential for bridging the gap between academia and business by means of co-creating innovative solutions and commercialisation of research results; (4) potential for running businesses in the sectors generally perceived as innovative – related to computerisation, communication and scientific and research activities. The schematic construction of the city innovative potential index (CIP index) is presented in Figure 1.

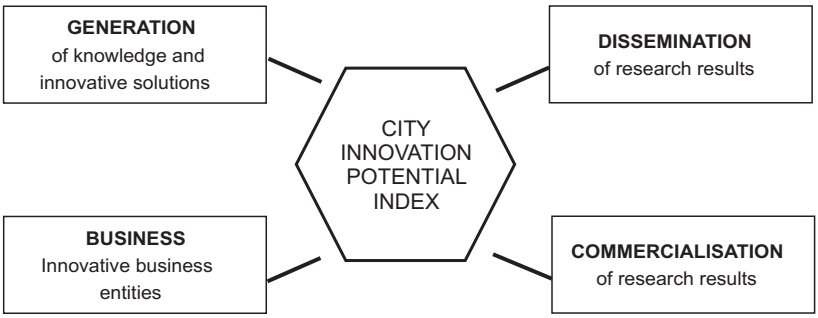

Fig. 1. Factors of the City Innovation Potential index (CIP index)

Source: prepared by the author.

Such an approach to the measurement of innovation potential in cities is determined, on the one hand, by the limitations in access to data, especially with regards to smaller cities and, on the other hand, by a drive to create a relatively straightforward measure which would still remain consistent with the literature on the nature of innovativeness, as discussed in the introductory part of the article.

The first group of factors which describe the analysed phenomenon relates directly to the scientific sector where knowledge is generated. The CIP index uses data on the number of international awards for: (1) research institutions, (2) research teams and (3) individual researchers. Each of the received awards is included in the CIP index of the city where the awarded institution is located or with which the awarded researchers are affiliated.

The second set of data used for constructing the CIP index relates to the activities which are, to a degree, responsible for generating knowledge and innovations, but more for dissemination of innovative solutions. The construction of the CIP index uses the data on the number of international scientific conferences as well as the number of local scientific conferences organised by research institutions located in various cities. In this approach, the conferences, and thus the cities themselves, are perceived as nodes for an exchange of thoughts and ideas which affect the development of innovations.

The third dimension which the CIP index reflects relates to the creation of new solutions which are generated in a given city and are subject to a successful patent application by a research institution or another entity. This approach is based on a sim-

plifying assumption as this aspect of innovation potential is without a doubt linked with an increased efficiency of economic processes also beyond the place where the innovation is generated – once published, the new knowledge becomes part of public domain (Lever 2001: 866). However, including this indicator in the construction of the CIP index allows capturing the bridge between academia and business.

The last factor attempts to determine the innovation potential of cities by means of the number of functioning as well as the number of newly-established economic entities in the sectors of the economy which are related to computerisation, communication as well as scientific and research activities. The analysis is based on a number of economic entities classified in the following sections of the Polish Classification of Activities: J-61, J-62, J-63, M-71, M-72.

Table 1 presents all the categories of data used for determining the city innovation potential index for Polish urban communes,[1] together with information on their weights. The ensuing analysis is based on the data for the period between 2013 and 2016. The data in the first, second and third groups of indicators were taken from the Integrated System of Information on Science and Higher Education (POL-on), while the data for the fourth group were taken from the Local Data Bank of Statistics Poland. All partial indicators were quoted relative to the number of inhabitants of cities and subsequently unitarized in order to facilitate interpretation (Becla, Zielińska 2003: 146-147).

Table 1

Factors and partial indicators of the City Innovation Potential Index

City innovation potemtial index	Factor	Partial indicator	Weight
	GENERATION of knowledge and innovative solutions	number of international awards for research institutions	0.100
		number of international awards for research teams	0.100
		number of international awards for individual researchers	0.050
	DISSEMINATION of research results	number of international scientific conferences	0.100
		number of local scientific conferences	0.150
	COMMERCIALISATION of research results	number of successful patent applications	0.250
	BUSINESS Innovative business entities	number of economic entities (sections according to Polish Classification of Activities: J-61, J-62, J-63, M-71, M-72)	0.125
		number of newly established economic entities (sections according to Polish Classification of Activities: J-61, J-62, J-63, M-71, M-72)	0.125

Source: prepared by the author.

[1] This study concentrates on Polish communes which have the status of urban communes (i.e. the city is at the same time a commune). There are also cities which are part of the so-called urban-rural communes which consist of a city as well as a number of rural settlements and areas. They are not included in this study.

Based on the data which were collected for all Polish urban communes (306 cities), rankings were created in accordance with an average value of the CIP index for the period between 2013 and 2016. Using the average value of the CIP index over a four-year period reduces the impact of excessive volatility and is also assumed to be in line with long term impacts which the innovation potential generates for city development. The rankings include 303 cities, 3 territorial units were excluded as they changed their status to urban-rural communes during the period covered by the research: Czarna Woda (on 1 January 2014), Władysławowo (on 1 January 2015) as well as Pieszyce (on 1 January 2016).

3. Innovation potential of cities – analysis by regions

The first of the conducted analyses looks at the differentiation of innovation potentials of Polish cities by region. Table 2 presents the values of the CIP index (averaged out for the period between 2013 and 2016 – $CIP_{2013\text{-}2016}$) for top 3 cities in each of the regions. Table 2 as well as Figure 2 also present information on the median value as well as the average of the CIP index for all cities in each of the regions weighed by the number of cities' inhabitants.

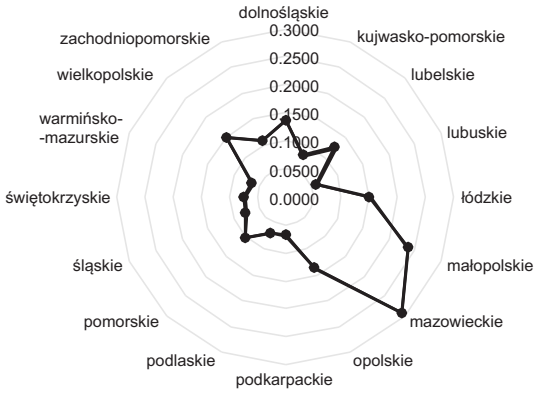

Fig. 2. Innovation potential of cities in Poland by region (weighed average of $CIP_{2013\text{-}2016}$)
Source: prepared by the author.

The analysed indicator reaches the highest values in cities located in Mazowieckie (Masovia) and Małopolskie (Lesser Poland) regions. The cities from Wielkopolskie (Greater Poland), Łódzkie (Łodz), Dolnośląskie (Lower Silesia), Opolskie (Opole) and Lubelskie (Lublin) regions follow, each achieving similar values of the CIP index. These results are consistent with the academic potential of higher learning institutions which operate in each of the regions and thus indicate where the leading academic centres are located in Poland.

Table 2

Innovation potential of cities in Poland by region

Region (capital city)	Rank	City	$CIP_{2013-2016}$	No. of inhabitants on 30 June 2016	$CIP_{2013-2016}$ regional median value	$CIP_{2013-2016}$ regional average weighed by the number of cities' inhabitants
Dolnośląskie (Wrocław)	1	Wrocław	0.3179	637 075	0.0213	0.1408
	2	Szczawno-Zdrój	0.0446	5 680		
	3	Oława	0.0405	32 674		
Kujawsko-Pomorskie (Bydgoszcz, Toruń)	1	Toruń	0.1798	202 591	0.0198	0.0812
	2	Bydgoszcz	0.1008	354 990		
	3	Golub-Dobrzyń	0.0240	12 830		
Lubelskie (Lublin)	1	Puławy	0.2430	48 526	0.0296	0.1245
	2	Lublin	0.2347	340 745		
	3	Biała Podlaska	0.0628	57 389		
Lubuskie (Gorzów Wlkp., Zielona Góra)	1	Zielona Góra	0.1172	138 898	0.0177	0.0590
	2	Gorzów Wielkopolski	0.0419	123 911		
	3	Żary	0.0204	38 197		
Łódzkie (Łódź)	1	Łódź	0.2631	698 688	0.0278	0.1490
	2	Skierniewice	0.0761	48 304		
	3	Konstantynów Łódzki	0.0452	17 868		
Małopolskie (Kraków)	1	Kraków	0.3421	762 448	0.0353	0.2360
	2	Sucha Beskidzka	0.0743	9 388		
	3	Nowy Sącz	0.0423	83 829		
Mazowieckie (Warszawa)	1	Józefów	0.3751	20 294	0.0340	0.2192
	2	Warszawa	0.3301	1 748 916		
	3	Zielonka	0.1513	17 508		
Opolskie (Opole)	1	Opole	0.1696	118 938	0.1362	0.1368
	2	Kędzierzyn-Koźle	0.1362	62 193		
	3	Brzeg	0.0302	36 381		

Table 1 contd.

Region (capital city)	Rank	City	$CIP_{2013-2016}$	No. of inhabitants on 30 June 2016	$CIP_{2013-2016}$ regional median value	$CIP_{2013-2016}$ regional average weighed by the number of cities' inhabitants
Podkarpackie (Rzeszów)	1	Rzeszów	0.1709	187 027	0.0311	0.0687
	2	Krosno	0.0399	46 695		
	3	Łańcut	0.0363	17 794		
Podlaskie (Białystok)	1	Białystok	0.1116	296 310	0.0241	0.0688
	2	Wysokie Mazowieckie	0.0327	9 427		
	3	Suwałki	0.0323	69 543		
Pomorskie (Gdańsk)	1	Gdańsk	0.2183	462 996	0.0264	0.1019
	2	Sopot	0.0983	37 089		
	3	Gdynia	0.0844	247 329		
Śląskie (Katowice)	1	Gliwice	0.3375	182 969	0.0269	0.0768
	2	Katowice	0.2252	299 012		
	3	Częstochowa	0.1551	227 270		
Świętokrzyskie (Kielce)	1	Kielce	0.1233	197 724	0.0264	0.0744
	2	Sandomierz	0.0311	24 124		
	3	Skarżysko-Kamienna	0.0264	46 656		
Warmińsko-Mazurskie (Olsztyn)	1	Olsztyn	0.1769	173 599	0.0190	0.0648
	2	Szczytno	0.0412	23 901		
	3	Iława	0.0269	33 181		
Wielkopolskie (Poznań)	1	Poznań	0.2969	541 561	0.0289	0.1507
	2	Puszczykowo	0.0501	9 778		
	3	Luboń	0.0460	31 196		
Zachodniopomorskie (Szczecin)	1	Szczecin	0.1773	405 413	0.0268	0.1097
	2	Koszalin	0.0801	107 981		
	3	Wałcz	0.0341	25 801		

Source: prepared by the author.

The above set of results also indicates the existence of significant differentiation in terms of city innovation potential within regions and, in most cases, the dominant position of regional capitals. The smallest differentiation of innovation potentials between cities within a region may be observed in Podlaskie, Lubuskie, Podkarpackie, Warmińsko-Mazurskie and Świętokrzyskie regions.

4. Innovation potential of cities – analysis by size category

The second analysis which is described in this paper concentrates on the city innovation potential analysed separately for six categories of cities by size. Two sub-groups of cities are identified in each of the categories which are regularly outlined by the Polish Statistical Office – Table 3 presents the size categories which are used for the purpose of further analyses.

Table 3

The number of analysed cities by size category

Size categories by Statistics Poland	Size categories assumed for analysis	Number of cities
Small cities (0; 20,000)	(0; 10,000)	48
	[10,000; 20,000)	68
Medium-sized cities [20,000; 100,000)	[20,000; 50,000)	100
	[50,000; 100,000)	48
Large cities (100,000 and more)	[100,000; 250,000)	28
	[250,000; +∞)	11
	Total	303

Source: prepared by the author.

Table 4 presents the values of the City Innovation Potential index averaged out for the period between 2013 and 2016 ($CIP_{2013\text{-}2016}$) for top 5 cities in each of the size classes. The table also highlights median values as well as average of the $CIP_{2013\text{-}2016}$ index weighed by the number of cities' inhabitants for all cities in each of the size categories. Figure 3 shows the dependence between the number of inhabitants of cities and their innovation potential – it includes all the cities apart from Warsaw which scores one of the highest values of the $CIP_{2013\text{-}2016}$ index and has close to 1.75 million inhabitants.

The results indicate that there exists a positive dependence between city size and innovation potential. There are, however, various exceptions from this general principle – some average-sized cities, such as Józefów or Puławy, achieve the City Innovation Potential index scores which are comparable or even higher than the largest of Polish cities. There are also some small cities whose innovation potential exceeds average values of CIP index for all cities – i.e. Zielonka, Sulejówek, Sucha Beskidzka. These cities may be considered to be case studies for future research.

Table 4

City Innovation Potential index in Polish cities by size category

Size category	Rank	City	$CIP_{2013-2016}$	$CIP_{2013-2016}$ median value per size category	$CIP_{2013-2016}$ average weighed by the number of inhabitants per size category
Large cities sub-group: [250,000; +∞)	1	Kraków	0.3421	0.2347	0.2710
	2	Warszawa	0.3301		
	3	Wrocław	0.3179		
	4	Poznań	0.2969		
	5	Łódź	0.2631		
Large cities sub-group: [100,000; 250,000)	1	Gliwice	0.3375	0.0406	0.0916
	2	Toruń	0.1798		
	3	Olsztyn	0.1769		
	4	Rzeszów	0.1709		
	5	Opole	0.1696		
Medium-sized cities sub-group: [50,000; 100,000)	1	Kędzierzyn-Koźle	0.1362	0.0296	0.0341
	2	Siedlce	0.0947		
	3	Biała Podlaska	0.0628		
	4	Słupsk	0.0581		
	5	Pruszków	0.0542		
Medium-sized cities sub-group: [20,000; 50,000)	1	Józefów	0.3751	0.0269	0.0364
	2	Puławy	0.2430		
	3	Otwock	0.1326		
	4	Sopot	0.0983		
	5	Skierniewice	0.0761		
Small cities sub-group: [10,000; 20,000)	1	Zielonka	0.1513	0.0221	0.0276
	2	Sulejówek	0.0950		
	3	Milanówek	0.0610		
	4	Konstantynów Łódzki	0.0452		
	5	Ustroń	0.0395		
Small cities sub-group: (0; 10,000)	1	Sucha Beskidzka	0.0743	0.0172	0.0225
	2	Podkowa Leśna	0.0553		
	3	Puszczykowo	0.0501		
	4	Szczawno-Zdrój	0.0446		
	5	Jordanów	0.0389		

Source: prepared by the author.

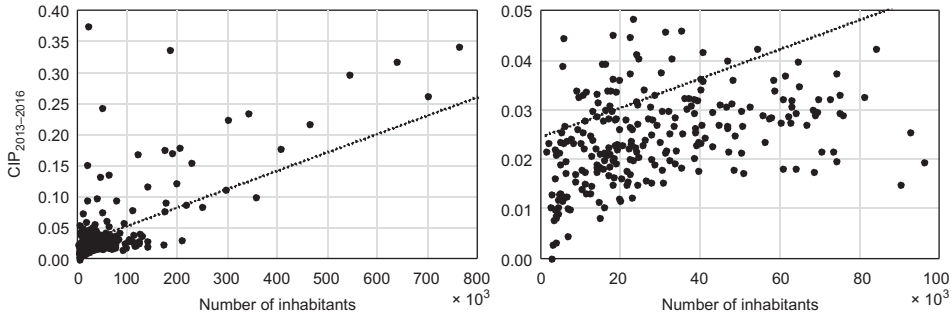

Fig. 3. City size and city innovation potential

Source: prepared by the author.

Once the general positive dependence between city size and innovation potential has been identified, the role of each of the factors (i.e. generation, dissemination, commercialisation and business) may be considered, especially for cities of different sizes. Figures 4, 5 and 6 show how significant each of the factors is in determining innovation potentials of cities ranked in the top 5 in each of the analysed size categories. Studying these results provides insights into the sources of competitive advantage of differently sized cities.

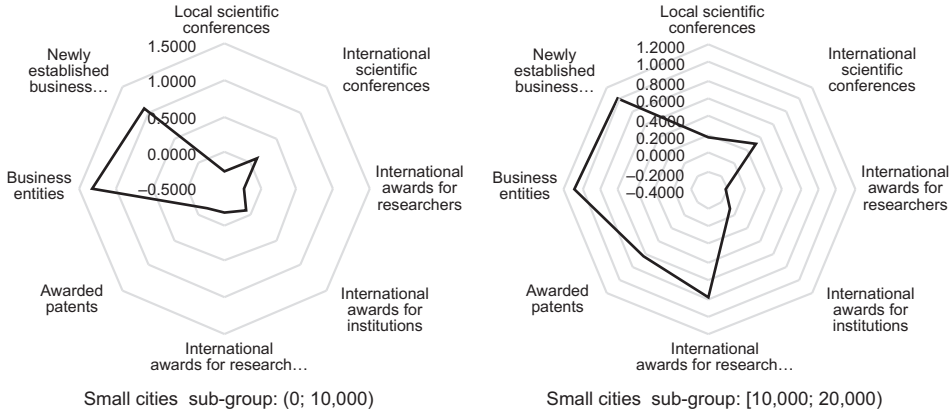

Fig. 4. Factors of city innovation potential per size category – small cities

Source: prepared by the author.

As expected, a change in the size of the analysed cities leads to a change in the impact of different factors. The innovation potential of the smallest of the cities (up to 10,000 inhabitants) is based almost entirely on the economic entities which operate in the fields perceived as innovative – here the business factor is the leading determinant. In the slightly larger cities (up to 20,000 inhabitants) the business factor is supplemented

by the factor of generating innovations, although its significance is not large enough to treat it as more than just supporting. The innovation potential of both these groups is visibly smaller than in the case of medium-sized or large cities which is in part caused by the fact that few scientific events (conferences) are organised in such cities and few academic institutions are based there.

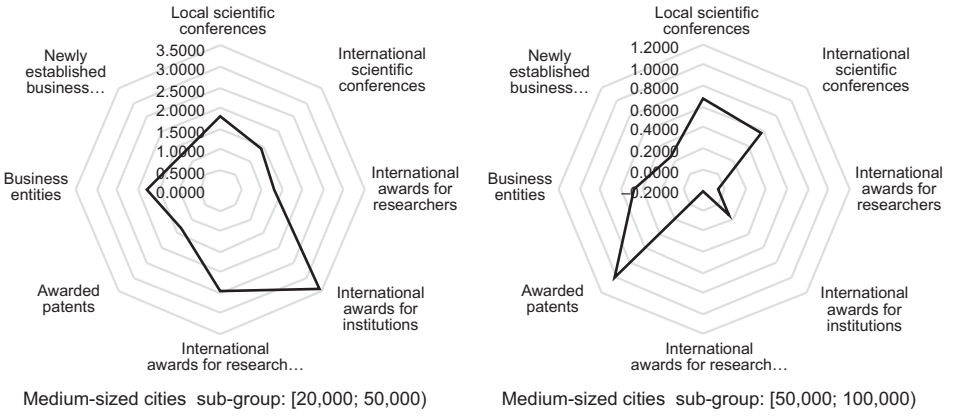

Fig. 5. Factors of city innovation potential per size category – medium-sized cities

Source: prepared by the author.

The situation of medium-sized cities (up to 50,000 inhabitants) is somewhat different. The innovation potential is in this case based mostly on the generating factor – two of the used indicators, namely the number of international awards for research teams and the number of international awards for research institutions achieve particularly high values. The innovation potential of medium-sized cities (up to 100,000 inhabitants) is determined mostly by the commercialisation factor and, to a much lesser degree, on the factor of generating innovations.

It is also worth emphasising that the top 5 cities with the population of up to 50,000 achieve considerably higher scores that their slightly larger counterparts. This is caused mainly by the extraordinary performance of Józefów which achieves the highest score for international awards for institutions (per number of inhabitants) in Poland, Otwock which ranks the 5th in Poland with regard to international awards for researchers (per number of inhabitants) and Puławy wich ranks the 1st in Poland insofar as international awards for research teams (per number of inhabitants) are concerned. These cities may be referred to as engines of development which manage to attract and retain considerable research activities. The analysis of individual cases goes beyond the scope of this paper but the causes for success of all three cities will be further researched.

As for the large cities (up to 250,000 inhabitants), the innovation potential is determined mostly by the generating factor and the commercialisation factor. The largest

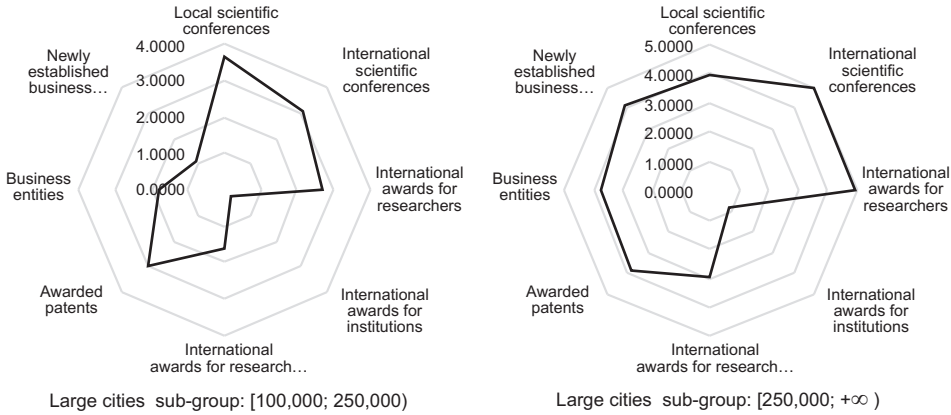

Fig. 6. Factors of city innovation potential per size class

Source: prepared by the author.

cities (250,000 and more) are the most coherent and balanced in terms of how the innovation potential is created. They achieve high scores in terms of the dissemination factor, commercialisation factor and business factor. Only the scores with respect to the generating factor are diversified, although even in this dimension the largest cities tend to dominate over their smaller counterparts.

5. Conclusions and future research

The analyses described in this paper indicate the existence of significant differentiation of innovation potential in cities across regions as well as within regions. There is also a clearly visible positive dependence between city size and the innovation potential of a city, although it needs to be emphasised that cities of varying sizes have different characteristics in terms of sources of their competitive advantages with regard to innovation potential.

Future research will aim at combining the characteristics of cities in terms of their innovation potential with measures for the culture-based and education-based potentials which are currently being developed. In the next step an analysis will be made of the role that each of these potentials plays in the development of cities (as measured by mostly economic indicators, such as *per capita* tax base).

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