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Innovation distance of Polish regions in relation to European models

Abstract: This article deals with the subject of the level of innovative development that is characteristic of Polish regions in comparison with other nations of the European Union. Among the main measures of innovation, the following factors were taken into account: patent activity, employment in the R&D sector, expenditure on R&D, and human resources for science and technology. Based on numerous studies indicating that this is an issue, an attempt has been made to measure the innovation gap in spatial and dynamic terms using a number of statistical tools. The innovation gap index, the innovation level change index and the patent advantage indicator were used as measures. Each of these methods takes into account certain measures of innovation (and their different approaches), which allows the problem to be comprehensively studied. Statistical data from the Eurostat, OECD and EPO databases for 2009–2017, which are related to the availability of data presented in regional innovation rankings, were used in the study. The results clearly show a disproportion in the development of Polish regions in relation to their European counterparts, but also in the direction of change over recent years. There are in addition symptoms of positive changes illustrated by detailed assessments of the indicators examined for selected Polish regions.

Keywords: high technology; innovation level; R&D sector; region; relative technological comparative advantage

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INTRODUCTION

The level of regional development depends on many factors. Some are endogenous and others exogenous. This development depends, on the one hand, on the resources at the region's disposal, on the other, the way these resources are managed. It also depends on the geopolitical situation at a particular time in which the region is operating, as well as external and internal factors determining changes. There are regions whose resources place them among the leaders in a given period due to the opportunity to exploit them.

However, changing reality can lead to far-reaching changes. Mono-sectoral development of a region is usually associated with a high risk of “falling” in the future. Examples of this are regions based on coal mining (Wałbrzych in Poland) or gold (Bodie Ghost Town in the USA). In today’s reality, regional and state authorities try to plan their future after they have exhausted opportunities by exploiting remaining limited resources.

Services, especially in the 20th century, achieved an advantage over production in producing wealth. The implementation of services is inherently much less costly than most production. What is more, we are dealing with a relatively inexhaustible source of new services, e.g. related to tourist attractiveness or the possibility of improving the resources needed to provide them, resulting in the employment of appropriately educated and targeted staff. The location of some regions helps tourist or transport services. However, the influence of the authorities is limited only to the organisation of a suitably adapted transport infrastructure and accommodation base, as well as additional attractions. There are also situations in which regions try to increase tourist attractiveness through appropriate investments. However, this is expensive and due to growing competition, requires continuous further technical investments (not always possible).

On the other hand, such a big impact on natural conditions is less likely. When striving for the level of development of a region, there is competition for funds and people. Development results from the local community which, in turn, depends on earning potential. Creating conditions for decent revenues, both in services and industry, is conditioned by the competitiveness of the offer resulting from the region’s attractiveness. The success of a given idea, solution or product can determine its uniqueness and demonstrate competitiveness. One of the main reasons for creating competitive offers compared to existing ones on the market is innovation. Innovation is the key to achieving a competitive advantage in the strategies of many regional enterprises and institutions. In this respect, it is possible to support, in contrast to existing geographical conditions, institutions interested in development (Zawada, Herbuś, 2014). This phenomenon is treated in the current literature (Firlej, 2013; Fritsh, Franke, 2004; Strahl, 2010) as a significant determinant of increasing importance.

The presented conclusions have been drawn using available data. The NUTS breakdown proposed by EUROSTAT may not be the most accurate, but it is difficult to find another with a comparable reporting level for EU spatial units. The comparability of some regions included in this ranking, which can be natural and also results from historical, economic, demographic and other problems noted by researchers, can be debated. Despite this, there is a constant “improvement” in NUTS nomenclature by combining small regions and dividing large or diverse ones. The study does not indicate one “ideal” pattern but refers to the results for Polish regions compared to others usually from the perspective of individual indicators.

INNOVATION IN REGIONS

Development based on innovation has become a fact. Virtually all countries are raising support of innovation among employees, organisations and society. Innovation is not definable. However, it is assumed that through a series of different types of activity focused on research and development (R&D), the implementation of patents, education, support for science, purchase of modern devices and technologies, attempts are

being made to build an innovation economy. However, depending on economic potential and the capacity for innovation in a given region, its potential and its political, geographical and economic situations, this level may be achieved more rapidly or slowly.

As a result of existing differences in the levels of development and rate of change between regions, innovative level is key. This is the gap that separates economic leaders, often also innovative, from others in this regard. From the point of view of the latter, but also those aspiring to higher positions in the ranking, it is important to clearly define the size of this gap as well as its pace of change and the possibilities of reducing it. Due to the high level of diversity in the assessment of many aspects of a given region, only some can be considered universal. On the other hand, the identification of individual aspects, rare or unheard of elsewhere, may indicate a chance to outperform competitors through specific tasks.

In an attempt to measure innovation, many problems regarding its unobservable nature must be faced (Acs, Anselin, Varga, 2002; Godin, 2011; Rogers, 1998). The analyses conducted so far focus either on input data such as expenditure on R&D, employment in the R&D sector (Sobczak, 2013), purchased technologies, or on output data (results) such as implemented innovations and pending or granted patents (Bolívar-Ramos, 2017).

One of the most frequently discussed topics in most regional strategies is innovation. In the European Union, due to the establishment of innovation policy, we are dealing with regional innovation strategies which indicate potential ways to develop innovation (Zioło, 2012). They usually lead by increasing R&D funding with the main focus being on directing the funds and activating the enterprise sector in this direction (Mesjasz-Lech, 2016). Another stimulus is to increase the value of human capital by increasing the level of education and increasing the number of technicians and engineers. Another, one on which regional authorities have no direct impact, is the increase in production (and services) from the so-called high technology industries, whose profitability is highest and whose future development prospects seem to be the best. The main task of regional authorities in this respect is to create innovative attitudes and to encourage, through administrative tools, legislative and procedural facilities, support for access to infrastructure and, if possible, fiscal relief. Although these tools do not provide direct benefits to potential investors, they can prevail in the process of making decisions about the location of investment. Activities aimed at bringing the research and industrial sectors together are also significant and the often-described innovation gap is mostly the result of poor adaptation at the research level with the commercial system (Huber, Kaufmann, Steinmann, 2014).

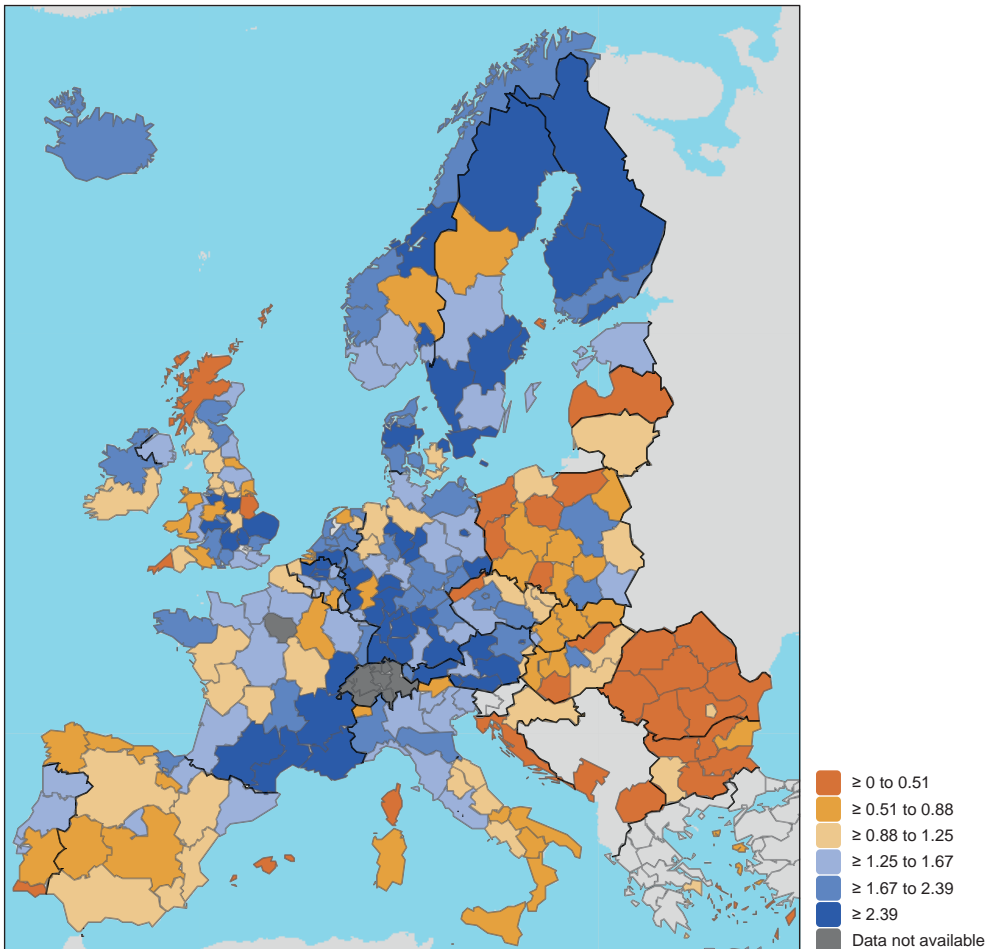
The Lisbon Strategy adopted by the European Union called for an increase in competitiveness for the European economy through the development of four pillars of which innovation was the first to be mentioned. The way to increase it was to increase expenditure on R&D by 2010 to 3% of GDP. Only Sweden, Finland and Denmark managed to achieve this goal, followed by Austria (2014) and Germany (2017). From the perspective of the 28 EU countries in 2017, expenditure on R&D reached only 2.07% of GDP. The goal was not achieved partly due to the financial crisis of 2008–2009. Apart from the relatively low level of financing of R&D activities in general, we observe a strong differentiation between individual countries as well as within countries on a regional basis. For example, in Lower Saxony in Germany, the Brunswick region spends nearly nine times more (in relation to GDP) than the Weser-Ems region. At the NUTS1 level,

Baden-Württemberg spends 5.62% of GDP, while Saxony-Anhalt only 1.5%. In Denmark, only one region, the strongest, exceeds 3%, and three out of five do not exceed 2%. In Sweden, half of the regions exceed the 3% indicator, but in Finland only the state capital does. In these countries, the division of regions into innovative and less innovative is clear. However, this does not prevent the achievement of sufficiently high results in comparison with other members of the European Union.

POLISH VOIVODESHIPS IN THE EUROPEAN UNION

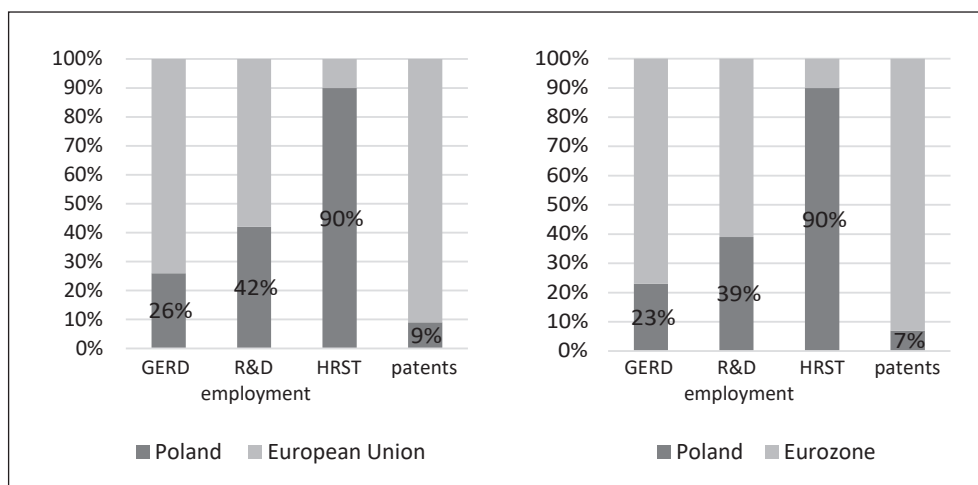
Against these observations, the situation in Poland (in terms of diversity of regions) seems to be similar (Fig. 1). The leading region in terms of expenditure on R&D, employment in this sector, and patent activity, is Mazowieckie Voivodeship (NUTS 2013) including the capital. However, when data for Poland is compared with EU averages, it turns out that the situation is highly unsatisfactory.

Figure 1. Intramural R&D expenditure (GERD) by NUTS 2 regions (2010) as % of GDP



Source: EUROSTAT

Figure 2. Gross expenditure on R&D (GERD), R&D employment, human resources for science and technology (HRST) and patents applied for in Poland compared to the average for the European Union and the Eurozone



Source: author based on EUROSTAT data

It turns out that expenditure on R&D in Poland constitutes only 26% of the average for the EU (Fig. 2), which was previously considered far from true. Employment in the R&D sector is also insufficient. Poland does better in the case of human resources for science and technology. Unfortunately, the combination of deficiencies means that patent activity, which is one of the measures of innovative activity, does not exceed 10% of the EU average. Attempts to raise its low level is usually (with limited resources) through appropriate specialisation, focused on potentially the most modern sectors. It could, therefore, be assumed that Polish regions specialise in fields considered to be highly innovative, described as high-technology sectors. To this end, the Relative Technological Comparative Advantage (RTCA) index was used (Weresa, 2014):

$$RTCA_{ij} = \frac{\frac{P_{ij}}{\sum_i P_{ij}}}{\frac{\sum_j P_{ij}}{\sum_i \sum_j P_{ij}}}$$

where:

- P_{ij} – number of patents in the region and in the sector j,
- $\sum_i P_{ij}$ – total number of patents in the j in the EU,
- $\sum_j P_{ij}$ – total number of patents in the region,
- $\sum_i \sum_j P_{ij}$ – total number of patents in the EU.

An index greater than one indicates the relative advantage of a region in a given sector over the EU as a whole. The use of measures based on variables that are a reference to certain aggregated data, as well as to the number of inhabitants or the professionally active, seems to increase comparability. Moreover, the use of certain authentication operations which increase comparability is also put forward in the literature, especially for countries rated as innovatively weaker (Cirera, Maloney, 2017).

Table 1. The occurrence of Polish regions in the top and bottom ten in a given high-tech field

Voivodeship	HT	Aviation	Computers	Communication technologies	Laser	Genetics	Semi-conductors
Łódzkie	x	▲	x	X	x	x	x
Mazowieckie	x	x	x	X	0	x	x
Małopolskie	x	x	▼	X	x	x	▼
Śląskie	x	x	x	X	x	x	x
Lubelskie	x	▲	x	X	0	x	x
Podkarpackie	x	0	x	X	0	x	▼
Świętokrzyskie	▲	x	▲	▲	x	x	x
Podlaskie	x	x	x	X	x	x	x
Wielkopolskie	x	x	x	X	x	▲	x
Zachodniopomorskie	x	0	x	▼	0	x	x
Lubuskie	x	▼	x	X	0	x	▼
Dolnośląskie	x	x	x	x	x	x	x
Opolskie	x	x	x	x	x	x	x
Kujawsko-Pomorskie	x	0	x	x	-	x	0
Warmińsko-Mazurskie	x	x	x	x	x	x	x
Pomorskie	x	x	x	x	x	▲	x

▼ – bottom-ten place, ▲ – top-ten place, 0 – no patents

Source: author based on EUROSTAT data

When analysing patent specialisation it would seem (Table 1) that the situation is not so bad. However, the RTCA indicator also has a drawback where a low number of patents are filed in a given area, even a small number for any sector will indicate its relative advantage. Therefore, the study also determined a comparability index (the ratio of the patent activity of a given region to the median for the EU), and its inverse as a measure indicating the pace needed to catch up with a comparable sector. The study used the median for two reasons. Firstly, the variation in the level of patent activity in all sectors is very high, and we note atypical observations limiting inferences using the arithmetic mean. Secondly, the level determined by the median is, in a way, the “EU average” and possible to be achieved in the foreseeable future.

Table 2. Index of relative technological advantage (median 2000–2012) for Polish regions

	HT	Aviation	Com-puters	Communi-cation technologies	Laser	Genetics	Semi-conductors	Comparative index (CI)	Catch-up rate 1/CI
Łódzkie	0.70	–	1.63	0.35	–	0.90	0.04	0.32	3.16
Mazowieckie	0.90	0.93	1.04	0.46	4.10	1.62	0.79	0.39	2.56
Małopolskie	0.36	0.16	0.53	0.28	–	0.41	0.20	0.37	2.67
Śląskie	0.63	0.88	0.61	0.63	0.53	0.36	0.62	0.15	6.48
Lubelskie	0.52	–	0.05	0.37	–	1.92	0.20	0.05	18.43
Podkarpackie	1.34	–	0.52	2.69	0.41	0.18	0.71	0.12	8.60
Świętokrzyskie	0.08	–	–	–	–	0.46	–	0.07	15.12
Podlaskie	0.29	–	0.44	0.12	–	0.66	–	0.02	47.46
Wielkopolskie	0.57	–	0.67	0.50	0.19	1.25	0.09	0.17	5.82
Zachodnio-pomorskie	0.85	–	0.56	0.28	–	3.14	0.93	0.19	5.27

Lubuskie	3.19	-	3.66	5.81	-	-	-	0.32	3.09
Dolnośląskie	1.05	0.19	1.04	1.02	0.88	1.62	0.23	0.23	4.26
Opolskie	1.12	-	0.28	2.20	-	0.71	-	0.18	5.41
Kujawsko-Pomorskie	0.33	-	0.65	0.30	-	0.47	-	0.12	8.06
Warmińsko-Mazurskie	0.51	-	0.53	0.45	-	0.95	-	0.05	20.22
Pomorskie	0.51	-	0.29	0.42	-	1.29	0.21	0.17	5.93

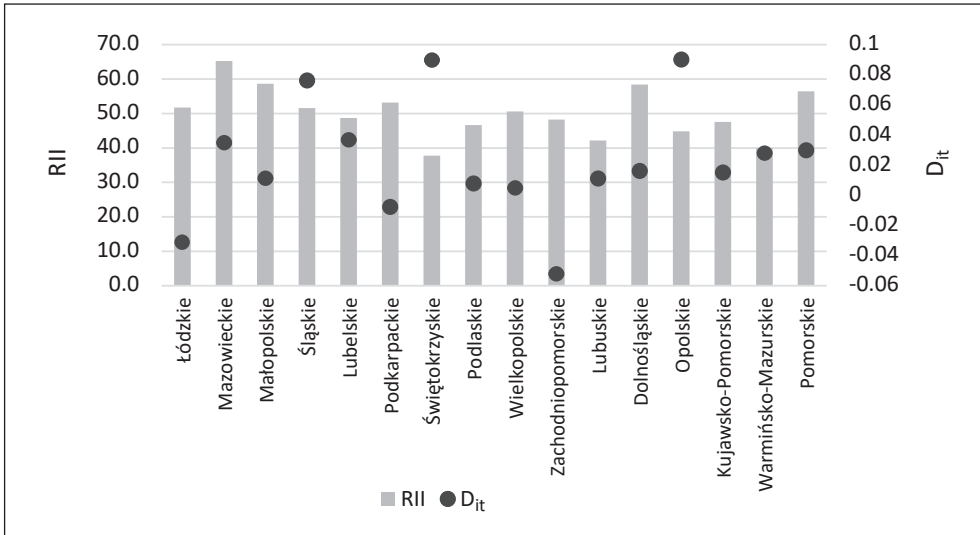
Source: author based on EUROSTAT data

Out of 16 voivodeships, in ten we observe specialisation in a given sector, while for some, the high technological advantage rate applies to more than one sector e.g. four in Dolnośląskie (Table 2). In this comparison, Świętokrzyskie Voivodeship fares the worst – no patents in most high-tech sectors with low patent activity in general – 0.07 EU median. Apart from the lack of specialisation, this is not the worst result, because Warmińsko-Mazurskie (0.05) and Podlaskie (0.02) show an even lower effect. The best are Małopolskie (0.37) and Mazowieckie (0.39) voivodeships. In the latter case, the technological advantage index for patents in the field of laser technology (4.10) indicates possible progress as it is higher than the catch-up ratio. Similarly, we note higher values for the Lubuskie Voivodeship in three aspects. Here too, we can expect a clear increase in patent activity in the near future. Focusing research and innovation activities on selected high technology sectors, which we observe in some of the analysed regions, should bring clear, positive effects in the long run. It should be remembered, however, not to give up on research in other regions which could also bring measurable benefits (Schienstock, Hamalainen, 2001).

In the light of innovation rankings, we also observe some changes not so much in leading as in catching up with the “average”. Polish regions are in this ranking in distant places. The highest, 143rd out of 202, is Mazowieckie Voivodeship and half of all the voivodeships occupy the bottom twenty places. These voivodeships did not even reach half of the points available (Fig. 3). The positions in the innovation ranking of Polish regions are not only quite low; in practice, they are falling. Only Zachodniopomorskie, Łódzkie and Podkarpackie improved their rankings. Meanwhile, all the other voivodeships lost both rating and place in the ranking; Śląskie was down by 19 positions and Opolskie by 16.

These findings are based on data from rankings prepared by international institutions. Bearing in mind the possible disadvantages of this, it is assumed, however, that they are the most reliable thanks to the experience and the objectivity resulting from the independence of the institutions creating them. The method of recognising the variables in subsequent years has undergone some correction related to the development of knowledge about the analysed topic. However, from comparability, we can treat the results obtained as appropriate to the situation on the international market and at the same time to the knowledge possessed in a given period. We can also find analyses covering foreign investments in individual (including innovative) sectors of the economy (Hong et al., 2019). However, their direct impact on innovation is more ‘blurred’. Attempts are being made to capture the information contained in this data through performance analyses, as well as performance and innovation gaps (Djellal, Gallouj, 2008). The analysis of the determinants of employment in knowledge-based sectors

Figure 3. Index of change in innovation level (D_{it}) on regional innovation ranking (RII) for Polish administrative regions: 2009–2017



Source: author based on RIS 2009, RIS 2017

is taken increasingly into account in place of previously used statistics on researchers employed in the R&D sector (Fernandes, Ferreira, Marques, 2015). Some of these indicators turn out to be appropriate for one type of economy, and not necessarily for others. High-technology economies will usually have high patent rates but not necessarily R&D spending, as these may, in turn, be higher in countries with a high proportion of industrial production often representing only medium technology. On the other hand, hardly identifiable service activities are neglected but they carry, especially in relation to financial markets and knowledge-based services, a large degree of innovation (NESTA, 2006).

A detailed analysis of data on the variables shaping the regional innovation index provides additional information (Table 3). Regions that have improved their places usually show a greater number of increases in the ratings of individual variables. In the case of Zachodniopomorskie, we do not note any high (above 0.5) changes. Podkarpackie has three variables, with a high rating increase. Six voivodeships show two clear falls, and Świętokrzyskie Voivodeship – three with only five moderate improvements. Overall in Poland, the weakest, adversely affecting the national economy, is the cooperation of SMEs with others in the field of innovation. For all voivodeships, there was a significant decline here except for Zachodniopomorskie. Other weaknesses are the sale of new products for companies as well as marketing and organisational innovations. By far the strongest side is education. A noticeable improvement also applies to expenditure on R&D. In the case of Polish administrative regions, only two in relation to public expenditure on R&D and three in relation to enterprise expenditure, show a relative increase in level (very small). The remaining have decreased, which is an improvement and in Podkarpackie significant.

What is the reason for this situation? Expenses for R&D in Poland differ significantly from those in the old EU countries. Braunschweig, the region spending the most

Table 3. Index of changes in innovation level for individual components of the regional innovation index (2007–2017)

	People with higher education	Public expenditure on R&D	Expenditure of enterprises on R&D	Expenditure on innovation outside R&D	Product and process innovations	Marketing and organisational innovations	SME innovations	Innovative SMEs cooperating with others	Public-private publications	Patent applications to EPO	Employment at MHT and KIS	Sales of products new to the market and for companies
Łódzkie	-0.43	-0.01	-0.02	-0.73	-0.11	0.42	0.09	0.67	-0.11	0.09	-0.19	0.57
Mazowieckie	-0.55	0.14	-0.26	-0.19	0.11	0.35	0.13	0.83	-0.18	0.13	-0.21	0.02
Małopolskie	-0.32	0.12	-0.10	-0.39	0.05	0.49	0.28	0.78	-0.05	-0.08	-0.35	-0.31
Śląskie	-0.27	-0.20	-0.04	0.27	-0.24	0.12	0.21	0.72	0.36	0.22	-0.14	0.70
Lubelskie	-0.44	-0.50	0.14	0.12	-0.18	0.03	0.23	0.78	0.19	0.05	-0.31	0.44
Podkarpackie	-0.38	-0.54	-0.53	-1.00	-0.20	0.31	0.16	0.79	0.49	0.36	-0.30	0.19
Świętokrzyskie	-0.42	-0.49	-0.09	0.48	-0.33	0.03	0.48	0.80	0.72	0.30	-0.37	0.71
Podlaskie	-0.39	-0.34	-0.11	0.58	-0.44	0.11	0.16	0.83	0.14	0.40	-0.22	0.50
Wielkopolskie	-0.34	-0.08	0.01	-0.18	0.15	0.30	0.11	0.62	0.02	0.17	-0.11	0.11
Zachodniopomorskie	-0.22	-0.18	-0.11	-0.42	-0.40	0.24	-0.10	0.31	-0.15	0.15	0.20	0.27
Lubuskie	-0.30	-0.11	-0.01	0.18	-0.32	0.70	-0.14	0.59	0.12	-0.07	-0.41	0.26
Dolnośląskie	-0.24	-0.08	-0.12	0.26	0.05	0.14	0.00	0.67	-0.02	0.33	-0.31	0.44
Opolskie	-0.38	-0.39	-0.05	0.40	-0.54	0.30	0.03	0.91	0.31	0.50	-0.31	0.97
Kujawsko-Pomorskie	-0.29	-0.27	0.13	-0.22	-0.38	0.30	0.21	0.80	0.32	0.35	-0.10	0.04
Warmińsko-Mazurskie	-0.17	-0.06	-0.09	-0.23	-0.41	0.03	0.35	0.68	0.35	0.11	-0.28	0.59
Pomorskie	-0.31	-0.19	-0.21	0.15	0.18	0.25	0.20	0.79	0.11	-0.01	0.01	0.45

■ – moderate increase, ■ – pronounced increase, ■ – moderate decrease, ■ – pronounced decrease

Source: author based on: RIS 2009, RIS 2017

(€3,175.7 per capita), spends over 6.5 times more than Mazowieckie, the strongest Polish voivodeship in this respect (€479.9 per capita). If we try to relate this value to Lubuskie, the weakest in Poland (€32.6 per capita), the proportion is 32 to 1. However, systemic failures cannot be blamed but rather neglect during the transformation. The strongest Polish region, the capital, spends 36% of what the Czech capital Prague spends (€1332.3 per capita). Thanks to this Prague is 15th and Mazowieckie 85th in the EU.

Another factor is the lack of similarity in regional definitions in the analysed years. This was changed in the NUTS amendment of 2018 when the capital city of Warsaw was separated from Mazowieckie Voivodeship. The results of this move in terms of statistical reporting will be observed in the coming years. Other Polish regions have positions below the first 150, and 11 are below 300. However, when it comes to employment in the sector, it is slightly better. The weakest Polish region, Lubuskie, is in 264th place, with British and Belgian regions still lower. In terms of employment, diversity is visible in practically all countries, and large discrepancies in levels for different regions of the same country can be considered almost typical. It is much easier, especially in a system with central management of funds for R&D and innovation policy, to direct financial resources than to organise appropriately selected and educated research staff.

CONCLUSIONS

The situation of Polish regions in the field of innovation is the result of many components shaping innovation policy in general. In terms of innovation, Polish voivodeships are low in all rankings. Patent activity at the regional level places them mostly below 10% of the median designated for regions of the European Union. However, analysing the reasons for this situation, the lack of clear specialisation of Polish voivodeships, and the low and not improving state of SME cooperation with others in the field of innovation, is noticeable. SMEs are one of the mainstays of innovation. However, there are positive symptoms too. The level of education in most regions is assessed at a level that promises to increase scientific and research potential in the future. The first indications of desired and potentially positive changes are visible, e.g. Mazowieckie voivodeship, for which the technological advantage index within laser technology already exceeds the catch-up factor and indicates possible faster progress. Data and indicators for almost all rankings for Lubuskie Voivodeship also allow moderate optimism. Unfortunately, it should be remembered that other regions have similar ambitions. Their faster development in the field of innovation has caused continuous declines in 13 out of 16 Polish regions. Regardless of the disadvantages of the rankings, and that they do not exactly faithfully reflect the real situation, is where Poland is at the moment. The role of rankings is opinion-forming and is taken into account in many investment and consumer decisions.

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