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R&D ACTIVITY AS A FACTOR OF REGIONAL COMPETITIVENESS

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Abstract: The paper is a reflection on the issues concerning the impact of research and development activities on competitiveness of polish voivodeships. Growing interest in the concept of regional competitiveness is associated with different processes, such as globalisation, internationalisation and regionalisation of the world economy. Competitiveness is determined by quantitative and qualitative factors; however, more attention should be focussed on qualitative determinants, including knowledge, technological progress and innovations, which are related to R&D activity. There are many different ways to measure competitiveness. One of the methods of assessment is making a reference to the regional competitiveness index (RCI) that shows strengths and weaknesses of regions. Taking into consideration that the largest disparities, both in the regional and national system, in relation to the EU average, are visible in three pillars constituting the Innovation Group indicators, it is worth conducting research on R&D development, as one of their key elements. Therefore, the goal of the paper is to present diversity in competitiveness of the regions in Poland, and to assess the level of development of R&D as one of determinants, having impact on competitive advantage. Implementation of the goal formulated in this way should be achieved through analyses concerning the following spheres: 1) the essence of regional competitiveness and its determinants; 2) the location of Polish regions in RCI ranking; 3) comparative analysis of the competitive potential of regions in the area of R&D.

Keywords: competitiveness, regional development, R&D.

1. Introduction

Along with the progressing process of globalization, internationalization and regionalization of the world economy, the intensity of competition on international markets and regional economic integration increase. For many years, these processes have been an important premise for the development of research on competitiveness and the factors determining it. Competitiveness is increasingly determined by qualitative factors related to technological progress, innovations, management systems, economies of scale etc., which, in the case of regions, lead to the development of smart specialization. Regions are beginning to compete in

a more sophisticated way, based on high-quality human capital, knowledge, innovation and related R&D.

Taking the above presumptions into consideration, the goal of the paper is to present diversity in competitiveness of Polish regions, and to assess the level of R&D development as one of determinants having impact on competitive advantage. The following research questions are formulated in the paper:

- What factors determine the competitiveness of regions?
- How are Polish voivodeships assessed in regional competitiveness rankings?
- How big are disparities between regions in the area of R&D development?
- Is there a relation between the level of R&D development and the region's competitiveness?

An attempt to answer these questions demanded dividing the paper into separate parts, including: 1) the essence of regional competitiveness; 2) the location of Polish voivodeships in RCI ranking; and 3) comparative analysis of R&D development in regions of Poland.

Conducted analyses, including mainly the changes of expenditure on R&D, expenditure on innovation activities, employment in R&D and number of granted patents, are based on statistical data collected by Statistics Poland (GUS). Due to the lack of more recent data, the analysis covers the years 2006-2016. On the other hand, establishment of the location of Polish voivodeships in Regional Competitive Index ranking required referring to data of the European Commission for the years between 2010 and 2016. Literature studies included Polish and foreign works on the subject in the area of competitiveness, including methods of assessment of competitive position of regions, as well as development of R&D and its measures.

2. Competitiveness of regions and their determinants

Considerations regarding the concept of competitiveness of various territorial structures, such as states, regions, cities and communes, and the construction of definitions corresponding to them, bring a lot of controversy, which is reflected in the lack of one generally applicable definition (Camagni, 2002; Kitson, Martin, and Tyler, 2004; Krugman, 2003; Porter, 2000, 2001, 2003; Bristow, 2005; Meyer-Steamer, 2008). This results from complexity of the subject of the definition, including determinants and instruments of development, diversity of business entities and the network of relationships and correlations occurring between them.

One of the first definitions for regional competitiveness comes from the Sixth Periodical Report on the Regions (1999, p. 10). It is defined as "the ability of a region to generate, while being exposed to external competition, relatively high income and employment levels". In other words, for a region to be competitive, it is important to ensure both the quality and quantity of jobs.

The concept is defined by the OECD in a similar way. It is stated, that competitiveness should be understood as "... the ability of companies, industries, regions, nations or supranational regions to generate, while being and remaining exposed to international competition, relatively high factor income and factor employment levels on a sustainable basis" (Hatzichronoglou, 1996, p. 20).

One of the definitions of regional competitiveness, that is most frequently applied in the literature on the subject, was developed by the European Commission experts (2000, pp. 23-24), who indicate that regional competitiveness is the ability to produce goods and services that find buyers on international markets, while ensuring high and permanent level of income. On the other hand, Meyer-Stamer (2008, p. 7) states that competitiveness of a territory is "the ability of a locality or region to generate high and rising incomes and improve livelihoods of the people living there". While (Dijkstra et al., 2011, p. 4) suggests that regional competitiveness can be defined as "the ability to offer an attractive and sustainable environment for firms and residents to live and work".

New approach is presented by Aiginger, Bärenthaler-Sieber and Vogel (2013), who define competitiveness as the "ability of a country (region, location) to deliver the beyond-GDP goals for its citizens". They focus on three pillars of competitiveness: the income pillar, that starts with GDP, but includes also disposable household income and consumption expenditure, the social pillar, which summarises indicators that reflect outcomes of a country's socio-economic system (poverty risk, inequality, youth unemployment), and the ecological pillar, that evaluates environmental outcomes.

Referring the concept of competitiveness to the level of the region, it can be assumed, that it is its ability to create conditions that allows it to generate relatively high income in the long period of time, using internal and external resources (human, financial and material), contributing to improving the conditions and quality of life of its inhabitants. It should be emphasized, that in all definitions presented, competitiveness is broadly understood – it allows to take into account not only traditional quantitative measures, but also qualitative factors, related to the structure of the economy, technological progress or the functioning of product markets and factors of production (Cambridge Econometrics, 2003; Budd, and Hirmist, 2004; Huggins, 2004; Huggins, Izushi, 2008; Boddy et al. 2005).

In definitions, but also in conducted studies, attention is focussed on several essential elements of regional competitiveness (Skórska, 2017), including:

- conditions of conducting business activity by enterprises,
- living standard of inhabitants,
- investment conditions,
- share of research and development activity in the region,
- business environment, including institutions and organisations (such as economic chambers, regional development agencies), as well as local and regional self-governments.

Depending on the adopted approach, definitions and measures of competitiveness can be divided into result-related and factor-related. The first of the aforementioned categories comprises of definitions referring to the results achieved by individual economies, while disregarding factors determining them, which, in turn, constitute the substance of the second group of definitions. These factors primarily include:

- structure of the economy,
- infrastructure,
- business environment,
- inhabitants' innovation and entrepreneurship,
- research and development base,
- education and general intellectual and cultural potential of the regional community.

In addition to endogenous factors, the regional competitiveness is also affected by exogenous factors, including the macroeconomic environment (e.g. the state's economic policy), the international environment, and especially participation in international economic integration processes. Factor measures allow to formulate conclusions about the state and possible changes in the potential and efficiency of a given economy.

These concepts are complementary towards each other and find reflection in research methodologies and summary indices that are developed, leading to an assessment of the state and competitiveness potential of regions and countries.

3. Polish voivodeships in Regional Competitiveness Ranking

Due to the complex character and ambiguous nature of regional competitiveness, its measurement and assessment encounters many obstacles (Berger, 2011; Kitson et al., 2004; de Martin 2005; Huggins, 2003). Berger (2011) presents a detailed overview on most of the indices to be found in the world, analysing them with respect to included indicators and predictive quality.

In conducted research, it can usually be performed in two ways: through decomposition of the general competitiveness into identified competitiveness factors, or through formation of special, synthetic competitiveness indices and measurements. Regional Competitiveness Index (RCI) is an example of this type of research applied in comparative analyses of regions of the European Union Member States. It is composed of 74 partial indices, divided into 11 pillars that describe various aspects of competitiveness.

Poland belongs to the group of countries with high internal differentiation of the level of regional development. The highest (150^{th}) place in the ranking is occupied by the Mazowieckie voivodeship, while the lowest (215^{th}) – the Warmińsko-Mazurskie voivodeship. However, it should be emphasised, that this diversity is not greater than in other European Union

countries. What separates us the most from the EU average, in the *Basic group* of indicators, are the areas related to institutions, infrastructure and health care. Macroeconomic stability is assessed at a similar level, while indicators related to the basic education are at a much higher level, as shown in Figure 1. Along with the development of the region, factors related to more qualified labour resources and effectiveness of labour market, included in the second group (*Efficiency group*), gain importance. They significantly determine the competitive position of regions in Poland. The largest disparities, both in the regional and national system, in relation to the EU average, are visible in three pillars constituting the *Innovation Group* indicators: Technological Readiness, Business Sophistication and Innovation, as shown in Figure 1.

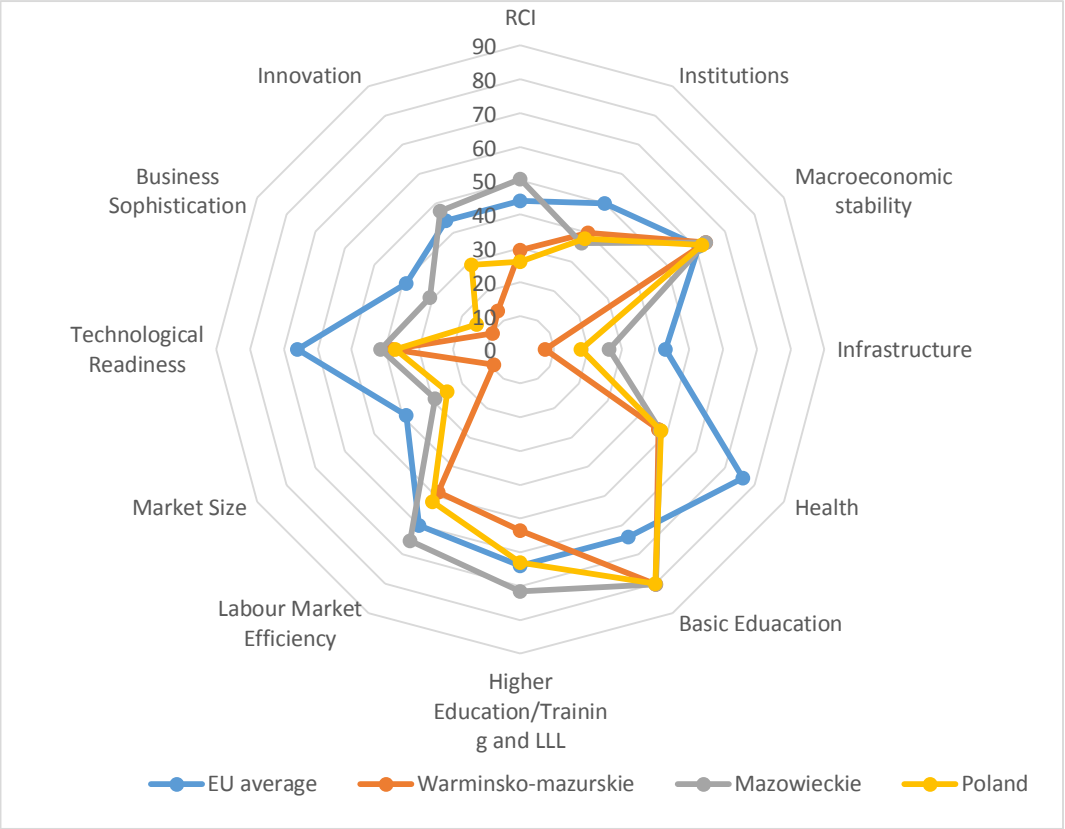

Figure 1. Regional benchmarking – RCI 2016. Source: own case study based on data retrieved from: https://ec.europa.eu/regional_policy/en/information/maps/regional_competitiveness/ (10.06.2019).

A more detailed analysis at the national level confirms, that the competitiveness of Poland's regional economies varies – see Table 1. Next to relatively well-rated voivodeships, e.g. Mazowieckie, Śląskie, Dolnośląskie or Małopolskie, on the map of Poland, there are also voivodeships assessed rather low – Warmińsko-Mazurskie, Kujawsko-Pomorskie, Podlaskie – regions that, for many years, have been dealing with numerous socio-economic problems.

Table 1.
Polish voivodeships in the RCI ranking in 2010-2016

Voivodeship	2010	2013				2016			
	RCI	Group I	Group II	Group III	RCI	Group I	Group II	Group III	RCI
Łódzkie	195	202	191	221	197	205	174	221	181
Mazowieckie	147	189	134	147	147	186	122	164	150
Małopolskie	176	183	186	203	184	170	155	211	171
Śląskie	168	188	164	215	175	185	149	219	170
Lubelskie	214	205	200	237	204	208	189	239	197
Podkarpackie	208	195	215	242	214	197	205	242	204
Świętokrzyskie	215	208	201	246	212	202	184	246	194
Podlaskie	228	207	202	243	211	196	215	241	211
Wielkopolskie	198	199	204	234	209	188	184	232	190
Zachodniopomorskie	209	201	206	220	207	198	195	228	198
Lubuskie	218	204	203	232	206	199	199	232	202
Dolnośląskie	187	206	185	209	190	205	171	200	177
Opolskie	204	186	197	231	196	187	209	232	205
Kujawsko-Pomorskie	219	210	211	233	215	200	205	244	211
Warmińsko-Mazurskie	230	211	233	236	230	202	212	243	215
Pomorskie	201	197	196	206	194	190	176	211	179

Source: Adapted from: The EU Regional Competitiveness Index 2010, by P. Annoni, K. Kozovska, 2010, JRC Scientific and Technical Reports, European Union, Luxembourg 2010, p. 221, The EU Regional Competitiveness Index 2013, by P. Annoni, L. Dijkstra, N. Gargano, 2013, JRC Scientific and Technical Reports, European Commission, pp. 124-127, by P. Annoni, L. Dijkstra, N. Gargano, 2017, The EU Regional Competitiveness Index 2016, Working Papers WP02/2017, European Commission.

At the same time, it should be emphasised, that low level of business sophistication and innovativeness are indicated among „bottlenecks" of some regional economies (Świetokrzyskie – 246th place in this area, Kujawsko-Pomorksie – 244th, Opolskie – 242nd). Technological Readiness and Business Sophistication indicate a significant deviation of the weakest regions of Poland from the EU average. For example, employment in the "Financial, real estate, professional, scientific and support activities" sectors (K-N) in Mazowieckie achieves 15% of total employment, while in Świętokszyskie it is less than 6%, in comparison to 23.6% in London, 22.7% in Antwerpia or 25% in Utrecht. The percentage of people using the Internet or shopping online is also significantly lower, and in the case of companies – level of technological adoption or firm-level technology absorption.

Strengths traditionally include: higher education, situation on labour market and large market potential (Mazowieckie – 122nd position in the ranking, Śląskie – 144th). Indicators from this pillar are steadily rising, which allows some regions to move to higher positions in the ranking. However, this is not a characteristic feature of all regions of Poland, because, in this area, regional diversity is also visible – 93 places between Mazowieckie and Podlaskie voivodeships.

It should be emphasized, that the indicators related to higher education in the majority of Polish regions exceed the EU average, which results, among others, from the percentage of population with higher educational, that has been growing for over two decades, and the reduction of the percentage of early school drop-outs. On the other hand, there is still

a problem with dissemination of the life-long learning concept. Relatively low percentage of adults participating in education and training negatively affects not only the obtained indicators, but, above all, the attractiveness on the labour market. Higher rates in this area can be found in: Denmark, Finland, France, the Netherlands or Great Britain.

The situation on the labour market is improving, which is reflected e.g. in decreasing unemployment rate. However, the relatively low employment level remains one of the key problems – it reaches from 44.8% in Warmińsko-Maszurskie to 63.3% in Łódzkie voivodeship, comparing to some regions of Germany or Sweden, where the employment rate exceeds 75%. Gender balance in employment also shows huge differences between female and male employment rates, in Poland it remains at 14-15 p.p.

Development processes, occurring in the region, are characterised by high complexity, therefore identification of key factors and assessment of their impact on competitiveness is complicated. The analysis confirms, that shift from II to III group of factors determining competitive position of the region requires taking more intensified activities that should be conducive to further development of Polish voivodeships. It is particularly important, because the regions, that occupy the leading positions in the competitiveness rankings, are also regions with a high level of innovation (Hollanders, Rivera Léon, Roman 2012, Porter 2001).

Therefore, it can be concluded, that in order to improve the competitive position of a given region, it would be necessary to create appropriate conditions for generating innovation through the activities of innovative and economic policy. This policy should contribute to the development of the local labour force, research and development potential of a region, innovative infrastructure and social capital.

In a long term, level of competitiveness depends mainly on the ability to maintain changes in factors generating productivity, i.e. technology, human resources, research expenditure and economy structures (Huggins, Izushi 2008). One of the most important factors, determining competitive advantage, is the potential of the R&D sphere. There is no doubt that searching for smart specialization of the region requires paying special attention to the economic structure, availability of infrastructure, business environment institutions and, above all, the advancement of research and development activities.

4. Assessment of the competitive potential of regions in the area of R&D

One of the crucial elements of the region's competitiveness is research and development, which determines the number and dynamics of product and technological innovations. The R&D sphere is a common area of the world of science and the world of economy, in which the progress of research work is translated into innovation. To put it simply, it can be assumed,

that the increase in innovation translates into a better competitive position, which is possible to achieve when research results are better utilized.

Taking into consideration research and development activities and their impact on competitiveness, most important indicators include:

- expenditure on R&D,
- expenditure on experimental development and applied research as share of total expenditure on R&D,
- expenditure on innovation activities per one employed in the industry,
- the number of patents granted per 100 employed in R&D,
- persons employed in R&D per 1000 in active population.

The basic indicator allowing to assess and compare the scope of R&D activities carried out in a given country or region is the sum of internal expenditure on research and development, called GERD (*Gross Expenditure on Research and Development*). In statistical analysis of research and development, the ratio of these expenditures to GDP of a given country (R&D intensity) is analysed the most often. It presents the ratio of total expenditure on R&D of four institutional sectors: business enterprises (BES), government (GOV), higher education (HES) and private non-profit (PNP) to the country's GDP.

Taking this into consideration, the European Union focuses on research and development, which was reflected in the Lisbon Strategy, implemented in 2000-2010, and its continuation in the form of the 2020 Europe strategy. One of their main goals was an increase in the investment in R&D to 3% of GDP till 2020. In the case of Poland, this goal has been set at 1.7% of GDP, yet it will still be difficult to achieve. Assuming the current growth rate, the ratio of GERD/GDP in 2020 will only approach 1.3% of GDP.

In 2006, internal expenditures on research and experimental development in Poland amounted to PLN 6.67 billion, constituting 0.56% of the GDP, which is shown in Table 2. The average annual growth rate of GERD in the period 2006-2016 remained at the level of 11.6%. In 2015, R&D intensity (GERD/GDP ratio) exceeded 1%, but in the following year, it decreased to 0.97% of GDP (PLN 18.06 billion). Despite the increase in GERD, when other GDP components also rise, ratio of GERD to GDP remains low. However, due to the high growth dynamics of GERD since 2007, Poland has come a little closer to the average of internal expenditure on R&D in the EU, which in 2016 reached 2.03% of GDP.

Among the EU Member States, Sweden recorded the highest R&D intensity (in 2016 it was 3.25%), which confirms, that Scandinavian economies focus on research and development. Austria and Germany achieved a comparable rate (3.09% of GDP and 2.94% of GDP, respectively). However, it should be noted, that Sweden has maintained a relatively stable, high R&D intensity over the last decades, while steady growth has been recorded in Austria and Germany since 2007.

Table 2.
Ratio of GERD to GDP in % (current prices) in 2006-2016

Voivodeship	GERD/GDP (%)											Change between 2006-2016 (p.p.)
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	
Poland	0.56	0.57	0.60	0.67	0.72	0.75	0.88	0.87	0.94	1.00	0.96	0.40
Dolnośląskie	0.35	0.41	0.44	0.53	0.51	0.54	0.69	0.65	0.74	0.85	0.69	0.34
Kujawsko-Pomorskie	0.35	0.20	0.22	0.56	0.31	0.27	0.42	0.31	0.34	0.46	0.35	0.00
Lubelskie	0.44	0.54	0.48	0.58	0.64	0.62	1.01	0.61	1.03	1.07	0.88	0.44
Lubuskie	0.10	0.09	0.10	0.10	0.14	0.16	0.20	0.26	0.18	0.22	0.20	0.10
Łódzkie	0.54	0.51	0.54	0.60	0.63	0.61	0.77	0.67	0.67	0.67	0.62	0.08
Małopolskie	0.92	0.92	0.95	0.93	1.00	1.01	1.31	1.30	1.38	1.49	2.16	1.24
Mazowieckie	1.07	1.07	1.21	1.19	1.36	1.39	1.37	1.55	1.70	1.74	1.66	0.59
Opolskie	0.16	0.14	0.14	0.23	0.12	0.25	0.19	0.23	0.34	0.32	0.36	0.20
Podkarpackie	0.39	0.36	0.37	0.37	0.92	0.90	1.01	1.22	1.38	1.29	1.05	0.66
Podlaskie	0.25	0.20	0.26	0.21	0.32	0.39	0.38	0.55	0.60	0.76	0.44	0.19
Pomorskie	0.51	0.51	0.57	0.52	0.60	0.71	1.07	0.98	1.05	1.12	1.14	0.63
Śląskie	0.36	0.38	0.36	0.55	0.46	0.52	0.63	0.62	0.57	0.61	0.53	0.17
Świętokrzyskie	0.08	0.12	0.27	0.42	0.45	0.36	0.30	0.35	0.34	0.61	0.31	0.23
Warmińsko-Mazurskie	0.18	0.29	0.23	0.31	0.44	0.48	0.48	0.36	0.27	0.32	0.33	0.15
Wielkopolskie	0.46	0.52	0.52	0.66	0.58	0.62	0.88	0.62	0.64	0.75	0.59	0.13
Zachodnio-Pomorskie	0.19	0.24	0.24	0.22	0.31	0.34	0.37	0.30	0.28	0.33	0.27	0.08

Source: own calculations based on www.stat.gov.pl. (12.08.2019).

Despite the high ratio of GERD to GDP in Sweden, expenditure on R&D in EUR billion gives it only the 5th place among all the Member States, which is related to the size of the economy. While GERD per capita in a given country strengthens the position of Sweden as a leader of innovation in Europe. Poland was 19th among the European Union countries.

The analysis of available data confirms the differentiation between the regions: the lowest R&D intensity in the entire research period is characterized by the voivodeships of Eastern Poland, including: Warmińsko-Mazurskie, Zachodnio-Pomorskie, Świętokrzyskie, while in the Western Poland – Lubuskie and Opolskie, as shown in Table 2. In the Lubuskie voivodeship it is 0.47% of national expenditure, which gives the region the last place in the country.

The highest expenditures on R&D, exceeding the average for Poland, were incurred in 2016 in Małopolskie and Mazowieckie voivodeships. In the Mazowieckie voivodeship, they amounted to PLN 6.86 billion, with a slight decrease compared to the previous year. The largest decrease was recorded in Świętokrzyskie (48.6%) and Podlaskie (decrease by 41%) voivodeships. On the other hand, in the Małopolskie voivodeship, an increase of over 50% in R&D expenditure (up to PLN 3.2 billion) was observed, thanks to which it maintained a high, second position in the country.

Taking into consideration innovation and competitiveness, not only the amount, but also the structure of R&D expenditure is important. It should be emphasized that, in Poland, approximately 54% of expenditure is allocated to experimental development, while in Pomorskie and Podkarpackie voivodeships it is over 63%, and 71% in Małopolskie

voivodeship. Lubelskie, Opolskie and Podlaskie voivodeships are regions where the share of expenditure on experimental development is almost three times lower than in Małopolskie voivodeship (about 25-27%). In the case of applied research, the differences are not so large, but also noticeable.

When analysing the changes of R&D expenditure and its structure, it is worth referring to the expenditure on innovation activities in enterprises, as shown in Table 3. Similarly to the previous case, the differences between voivodeships are visible. The largest expenditure on innovation activities, both in the industry and in the services sector, throughout the entire research period, was allocated in the Mazowieckie voivodeship. In 2016, it achieved 26.5% of total expenditure, which is reflected in the expenditure on innovation activities in enterprises per one active person, despite a slight decrease in these expenditures. The lowest expenditure per one active person is characterized by the Warmińsko-Mazurskie voivodeship and, what is important, in the years 2006-2016, it decreased by 32%. A similar trend was observed in the Kujawsko-Pomorskie, Opolskie, Podlaskie, Śląskie and Świetokrzyskie voivodeships, which raises some doubts.

Table 3.
Expenditure on innovation activities in enterprises per 1 active person (PLN)

Region/Time	2006	2008	2010	2012	2014	2015	2016	Change between 2006-2016	
								PLN	%
Poland	1 506	2 078	2 018	2 115	2 158	2 515	2 260	754	150.1
Dolnośląskie	1 031	1 612	1 747	0	3 006	3 330	2 710	1 679	262.7
Kujawsko-Pomorskie	1 054	2 516	1 297	0	1 447	1 240	1 041	-13	98.7
Lubelskie	528	858	542	857	588	550	670	142	126.9
Lubuskie	532	958	610	698	648	1 729	1 364	832	256.2
Łódzkie	472	1 920	0	1 871	2 445	0	0	1 972	517.4
Małopolskie	1 053	1 093	979	1 382	1 464	1 950	2 606	1 553	247.4
Mazowieckie	4 064	4 932	5 768	6 084	4 436	0	3 968	-96	97.6
Opolskie	809	841	718	0	677	752	0	-58	92.8
Podkarpackie	1 118	1 142	1 073	1 550	2 565	2 160	1 885	767	168.5
Podlaskie	1 027	862	0	999	525	699	830	-197	80.7
Pomorskie	1 633	3 101	2 665	1 301	1 943	1 972	2 201	569	134.8
Śląskie	2 149	2 414	2 338	1 890	2 070	2 140	1 956	-192	91.0
Świętokrzyskie	536	722	534	1 308	381	649	532	-4	99.2
Warmińsko-Mazurskie	573	553	579	0	533	919	388	-185	67.6
Wielkopolskie	1 223	1 571	1 148	1 424	2 186	2 425	1 745	523	142.7
Zachodnio-Pomorskie	571	746	923	1 667	1 658	2 736	1 024	453	179.6

Source: own calculations based on www.stat.gov.pl. (12.08.2019).

It is obvious, that increasing expenditure on research and development, as well as innovation activity in enterprises, should result in an increase in the innovativeness of enterprises and the entire economy. It seems indisputable that expenditure on R&D is an important factor creating innovation potential, but it is definitely not the only determinant. It should be stressed that, at the same time, expenditure on R&D has a positive impact on patent activity, treated as the strength of innovation potential.

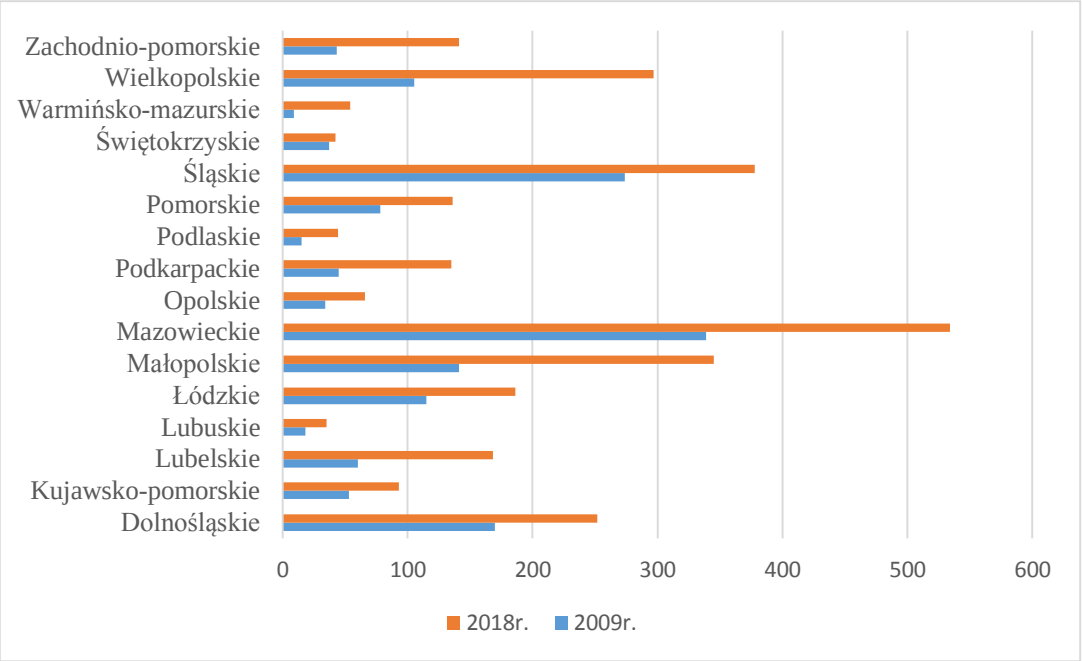

Figure 2. Patents granted by the Patent Office of the Republic of Poland in 2009 and 2018. Source: own calculations based on data retrieved from Local Data Bank https://bdl.stat.gov.pl/ (5.08.2019).

Consistently increasing the expenditure on R&D is reflected in the number of patent applications, utility models and granted patents; however, in none of the surveyed years or regions is it possible to point out a specific, clear trend. While in 2018, compared to 2009, more than 89% more patents were obtained in Poland, in 2016, the number of patents (3.37 thousand) was the highest, and in the subsequent years it began to decrease. Regardless of the analysed year, most patents were obtained in Mazowieckie, Śląskie and Małopolskie voivodeships, while the least in Lubuskie, Świętokrzyskie and Warmińsko-Mazurskie, as shown in Figure 2. It should be noted, that the number of patents obtained in Warmińsko-Mazurskie voivodeship in 2009 was only 9, and in 2018 – 54. Referring these data to the number of patents granted by the Patent Office of the Republic of Poland per 100,000 inhabitants, the average in the first three voivodeships is 9-10, while in the weakest – 3.4-3.8. This confirms the disparities between regions, especially between Eastern and Central Poland.

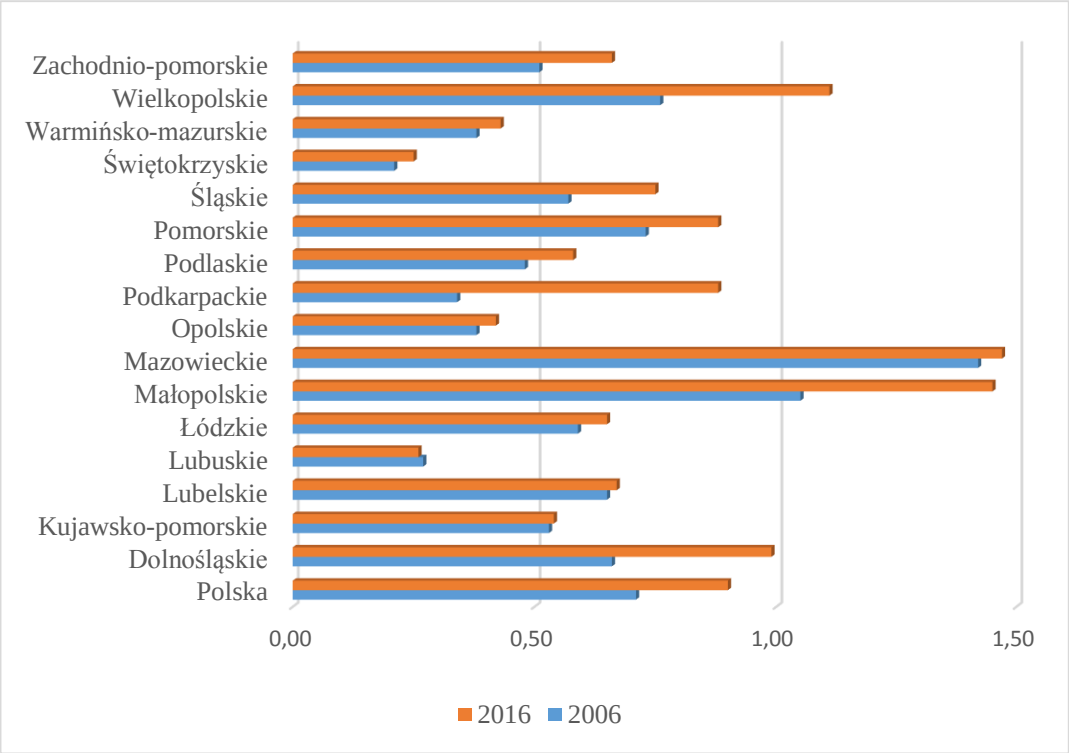

Figure 3. Persons employed in R&D as percentage of active population (%). Source: own calculations based on data retrieved from Local Data Bank https://bdl.stat.gov.pl/ (5.08.2019).

Activities in the R&D area and their results are largely based on the quality of human capital. The number of people constituting the personnel in the sector of research and development in Poland in 2016 reached 214 thousand people, of which 171.6 thousand persons represented internal personnel. Internal personnel conducting R&D in FTE in 2016 exceeded 88 thousand people. In 2016, almost 58% of R&D personnel was associated with the higher education sector, 36.8% with the business enterprise sector, and 5.3% with the government sector, together with the private non-profit sector. More than half of the R&D personnel performed their work in entities located in three voivodeships: Mazowieckie, Małopolskie and Śląskie, as shown on Figure 3. The lowest number of R&D personnel was recorded in Lubuskie – 0.7% and Opolskie – 1.1% of total R&D personnel. The largest number of employed was recorded in Mazowieckie – 29.2% and Małopolskie – 13.3%, with 73.3% and 83.4% of researchers employed in entities located in these voivodeships respectively. In Mazowieckie voivodeship, 40.0% of internal personnel are women. The lowest number of employed was recorded in Lubuskie – 0.7% and Świętokrzyskie – 1.0%. Over 87% of those employed in R&D in these voivodeships were classified as researchers.

Other data on employment in R&D confirm the deep differentiation between voivodeships, as shown in Figure 3. Although the direction of changes is the same, the number and percentage of those employed in R&D in the active population differ significantly. For example, in Dolnośląskie voivodeship, an increase in employment achieved almost 70 p.p., and in Małopolskie – 80 p.p. While in Świętokrzyskie, where there was a twofold increase in employment in R&D, the percentage of people employed in R&D in the active population

remained at the lowest level (increase from 0.21 to 0.25%). In Podkarpackie voivodeship, the increase was 3.5 times, which translated into an increase in the share from 0.33 to 0.88. As a result, the region was promoted from 13th to 6th place among voivodeships, as shown in Figure 3. In Lubuskie, it did not exceed 1%, in Opolskie it is 1%, while in Małopolskie – 13% and in Mazowieckie 33%. These values did not change significantly in the analysed period.

To sum up, taking into account the above analysis, three groups of voivodeships can be distinguished:

- voivodeships with the highest potential in the area of R&D (and place in the competitiveness ranking) – Mazowieckie, Małopolskie, Śląskie, Dolnośląskie,
- voivodeships with average potential in the area of R&D – Łódzkie, Wielkopolskie, Pomorskie, Zachodnio-Pomorskie, Lubelskie,
- voivodeships with the lowest potential in the area of R&D – Warmińsko-Mazurskie, Świętokrzyskie, Podkarpackie, Podlaskie, Lubuskie, Opolskie, Kujawsko-Pomorskie.

Conclusion

The role of Polish regions, that they play in the European and world economy, will depend on their competitive position. Competition between regions is now becoming more and more sophisticated. It is won by those regions, that have focused on innovation and the development of knowledge-based sectors, in which R&D plays a special role.

Polish voivodeships are characterized by a great diversity of their competitive potential, including the area of R&D. These differences result from their geographical location, historical conditions, size, diverse responses to the transformation processes, as well as different economic structures. For many years, Mazowieckie voivodeship has remained the leader in various rankings, while the last places are occupied by the regions located in the Eastern Poland, including Warmińsko-Mazurskie and Podkarpackie voivodeships.

Increasing competitiveness, especially of that part of Poland, is an important goal of regional policy, but it should be emphasized, that it will require basing on own new technologies and their transfer as part of cooperation between organizations focused on creating innovation as part of R&D activities. Insufficient support of R&D means that Poland, especially some regions of the country, has low innovation potential. Therefore, if Poland wants to increase its competitiveness in a long term and, at the same time, wants to reduce the distance to highly developed countries of the European Union, it must stimulate the creation and development of innovative enterprises. To achieve this, it is necessary to increase expenditure on R&D and change its structure, developing scientific potential, increasing expenditure on education and extension of programs enabling the improvement of professional qualifications. In this regard,

the state's support of initiatives related to the creation of modern forms of enterprise cooperation, including cooperation with scientific and research units, will be useful.

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