

# R&D Expenditures in Poland. Voivodship Perspective

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## Abstract

*The main purpose of the paper is R&D expenditures analysis at the level of Poland's voivodships. First, the significance of R&D expenditures in development of region competitiveness is considered. Next, intramural expenditures on R&D by NACE 2007 sections and by fields of science in particular are examined within a voivodship perspective. Subsequently, a comparison of R&D expenditures between Poland's voivodships is conducted. Particular attention is paid to such variables as: persons employed in R&D per 1000 economically active persons, units with research and development activity by sectors of performance, intramural expenditures on R&D per capita, extramural expenditures on R&D and intramural expenditures on R&D in the business enterprises sector. The study is based on cluster analysis, which provided a cluster distance matrix and is based on data from the Central Statistical Office of Poland — Local Data Bank.*

**Keywords:** R&D expenditures, knowledge transfer, competitiveness of regions, voivodship

## Introduction

R&D expenditures constitute an important dimension of a region's knowledge and innovation potential. R&D expenditures distinguish a region's capacity for knowledge creation. Accordingly, R&D expenditures should be considered crucial determinants of regional improvement and increasing competitiveness. Therefore, operations relevant to the stimulation of R&D activity take central stage within the European Union's Lisbon Strategy and Strategy Europe 2020, which highlight the enhancement of European competitiveness.

The main objective of this article is R&D expenditures analysis in the perspective of Poland's voivodships. Principal attention is drawn to a multidimensional comparison of R&D expenditures between particular voivodships using such variables as intramural expenditures on R&D by NACE 2007 sections and by fields of science, persons employed in R&D per 1000 economically active persons, units with research and development activity by sectors of performance, intramural expenditures on R&D per capita, extramural expenditures on R&D and intramural expenditures on R&D in the business enterprises sector. Cluster analysis is used as a research tool for the creation of a cluster distance matrix. The analysis uses data from the Central Statistical Office of Poland—Local Data Bank.

## 1 R&D expenditures as the substantial component of regional competitiveness

Issues relevant to R&D expenditures are associated with innovation concerns. In that area particular attention is drawn to a region's innovation, which is of significant interest within the European Union. Nowadays the range of innovations is clearly noticeable. Innovations impact regional development and its level of competitiveness. That is why innovations are treated as the key factor in regional development dependent on a region's knowledge transfer (Łażniewska and Gorynia 2012, 137). The significance of innovations is shown not only in increasing a region's competitiveness but also upon firms, which conduct their business in the region (Zygmunt 2013a, 1–7; 2013b, 129–134; 2013c, 1002) and implement new technologies towards transformation into new products and services (Klemens 2013, 153). It should be pointed out that a region's ability

to generate innovation requires the development of a so-called learning region with a knowledge-based economy (Chądzyński, Nowakowska, and Przygodzki 2012, 142). Innovations encourage entrepreneurship of the firms which conduct their activity in a particular region. Consequently, increasing entrepreneurship might drive a region's competitiveness. In this regard an essential role is played by a region's R&D potential, which is expressed mainly by R&D expenditures sustained especially by companies. The R&D level assigns an integral aspect of knowledge transfer (Cummings and Teng 2003, 50), which reflect a region's competitiveness. It has to be said that knowledge transfer enhances enterprises' innovative behaviour. In the aftermath, knowledge transfer impacts improvement in R&D and increases enterprise development, which affects regional competitiveness enhancement.

The substance of innovation and, in consequence, R&D expenditures requires taking into consideration the operations which encounter innovations and entrepreneurship in a region.

## 2 The methodology of the research

The research covers R&D expenditures analysis in Poland's voivodships, over the period of 2008–2012 and is based on data from the Central Statistical Office of Poland — Local Data Bank. The studies were divided into two parts. At first, a diagnosis was made of the level of intramural expenditures<sup>1</sup> on R&D by NACE 2007 sections and by fields of science in particular voivodship contexts. Secondly, a multidimensional comparison of R&D expenditures between Poland's voivodships was conducted. Cluster analysis was applied to create a cluster distance matrix. In the first step the increased emphasis was on the selection of analysis variables to characterize R&D expenditures of Poland's voivodships. The following variables were chosen:

- $x_1$ —an average of persons employed in R&D per 1000 economically active persons in each voivodship
- $x_2$ —an average of units with research and development activity by sectors of performance in each voivodship
- $x_3$ —an average of intramural expenditures on R&D per capita in each voivodship
- $x_4$ —an average of total extramural expenditures<sup>2</sup> on R&D in each voivodship
- $x_5$ —an average of intramural expenditures on R&D in the business enterprises sector in each voivodship

The above variables were employed to create a data matrix ( $X = [x_{ij}]$ ), which constitutes the basis for comparison of R&D expenditures between Poland's voivodships during the period 2008–2012. Next, the determined data matrix ( $X = [x_{ij}]$ ) was standardized under the following formula (Kukuła 2000, 82):

$$(1) \quad z_{ij} = \frac{x_{ij} - \bar{x}_j}{S_j}, \text{ when } x_j \text{ is stimulant}$$

or

$$(2) \quad z_{ij} = \frac{\bar{x}_j - x_{ij}}{S_j}, \text{ when } x_j \text{ is destimulant}$$

where:

$z_{ij}$ —standardized diagnostic attribute  $x_{ij}$ ,

$$\bar{x}_j = \frac{1}{n} \sum_{j=1}^n x_{ij}, \text{ and } S_j = \sqrt{\frac{1}{n} \sum_{j=1}^n (x_{ij} - \bar{x}_j)^2}.$$

1. Intramural expenditures on R&D are defined as current expenditures and investment outlays on fixed assets related to R&D activity without depreciation of these assets, see: [http://stat.gov.pl/cps/rde/xbcr/wroc/ASSETS\\_Dzialalnosc\\_badawcza\\_i\\_rozwojowa.pdf](http://stat.gov.pl/cps/rde/xbcr/wroc/ASSETS_Dzialalnosc_badawcza_i_rozwojowa.pdf).

2. Extramural expenditures on R&D activity are defined as expenditures on R&D obtained from other domestic and foreign contractors or subcontractors together with contributions and other resources, see: [http://stat.gov.pl/cps/rde/xbcr/wroc/ASSETS\\_Dzialalnosc\\_badawcza\\_i\\_rozwojowa.pdf](http://stat.gov.pl/cps/rde/xbcr/wroc/ASSETS_Dzialalnosc_badawcza_i_rozwojowa.pdf).

Subsequently, the studies required the selection of the similarity measure. The following was chosen (Młodak 2006, 48)

$$(3) \quad d_{ij} = \sqrt{\sum_{k=1}^m (z_{ik} - z_{jk})^2}.$$

The similarity measure was applied to compute distances between particular voivodships, which enabled the creation of a cluster distance matrix and a comparison of R&D expenditures between Poland's voivodships.

### 3 R&D expenditures comparison between Poland's voivodships

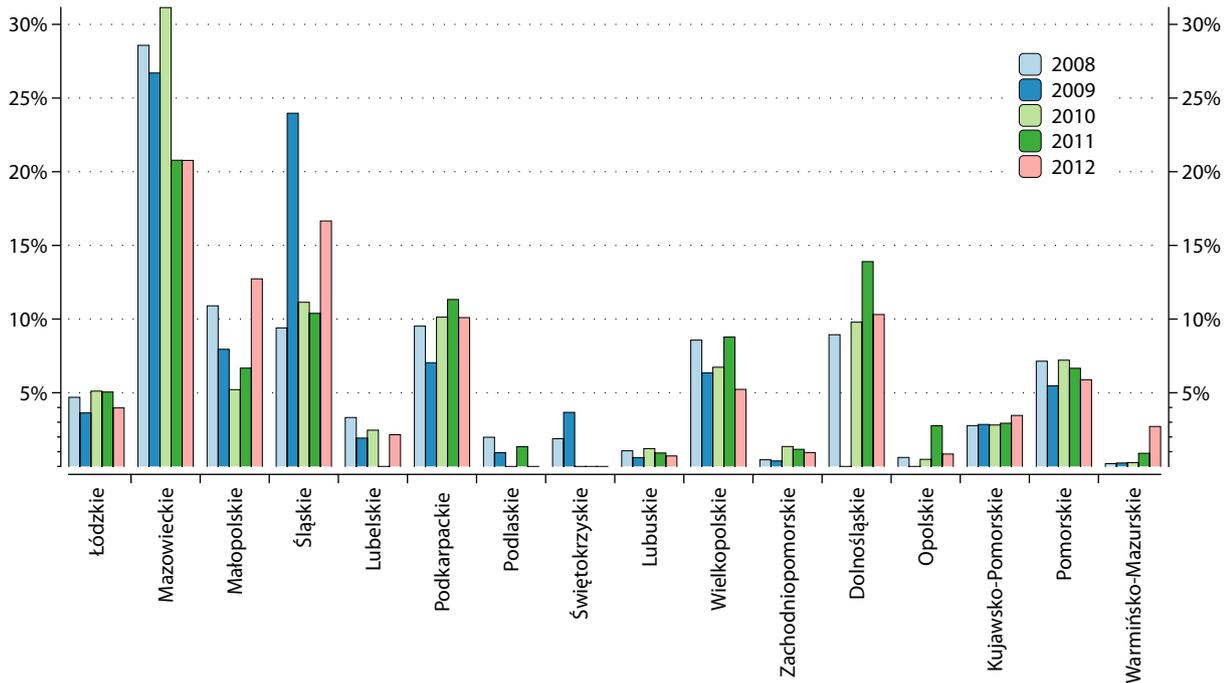
The results of analysis indicate discrepancies between the level of intramural expenditures on R&D in Poland's voivodships. At the NACE 2007 sections setting, which specify activities connected with mining and quarrying (section B), manufacturing (section C), electricity, gas steam and air conditioning supply (section D) and water supply, sewerage, waste manufacturing and remediation activities (section E) it is seen that in half of Poland's voivodships intramural expenditures on R&D amounted to more than 5% in the period 2008–2012 (on average), while in one quarter of voivodships R&D expenditures totalled less than 0,84% (on average) for Poland within 2008–2012. Among Poland's voivodships relatively low level expenditures on R&D in the industries sections was identified in Podlaskie (NUTS PL 34) (0,85% on average), Zachodniopomorskie (NUTS PL 42) (0,85% on average), Warmińsko-Mazurskie (NUTS PL 62) (0,85% on average), Lubuskie (NUTS PL 43) (0,90% on average), and Opolskie voivodships (NUTS PL 52) (0,94% on average) (fig. 1).<sup>3</sup> The comparatively low level of expenditures on R&D in these voivodships might arise from the character and structure of industry, which distinguish a particular voivodship. After all, insistence on increasing regional competitiveness and knowledge transfer requires the engagement of operations which should be concentrated on enhancing the level of intramural expenditures on R&D in the above voivodships. On the other hand, a relatively high level of intramural expenditures on R&D in the period 2008–2012 distinguished Mazowieckie (NUTS PL 12) (25,60% on average), Śląskie (NUTS PL 22) (14,31% on average), Podkarpackie (NUTS PL 32) (9,62% on average) and Dolnośląskie voivodships (NUTS PL 51) (8,59% on average). This might result from the relatively high development of industrial sectors in these voivodships.

The examinations of intramural expenditures on R&D by NACE 2007 sections other than industries in Poland's voivodships in 2008–2012 moves toward the conclusion of a trend similar to that for industries (fig. 2).

Simultaneously, the results emphasise that in several of Poland's voivodships intramural expenditures on R&D in sections other than industry was relatively higher than in sections connected with industry. An essential distinction is noticeable especially in Mazowieckie (NUTS PL 12), Małopolskie (NUTS PL 21), Wielkopolskie (NUTS PL 41), Łódzkie (NUTS PL 11), Lubelskie (NUTS PL 31), Zachodniopomorskie (NUTS 42) and Warmińsko-Mazurskie voivodships (NUTS PL 62). That results from the essence of activities which are conducted in these voivodships. Additionally, the results of analysis indicate the comparative level of intramural expenditures on R&D by NACE 2007 sections other than industries and that connected with industries in Poland's voivodships in 2008–2012. That situation should be treated as positive because it provides background for knowledge transfer and innovation increases, which might constitute improvement a region's competitiveness.

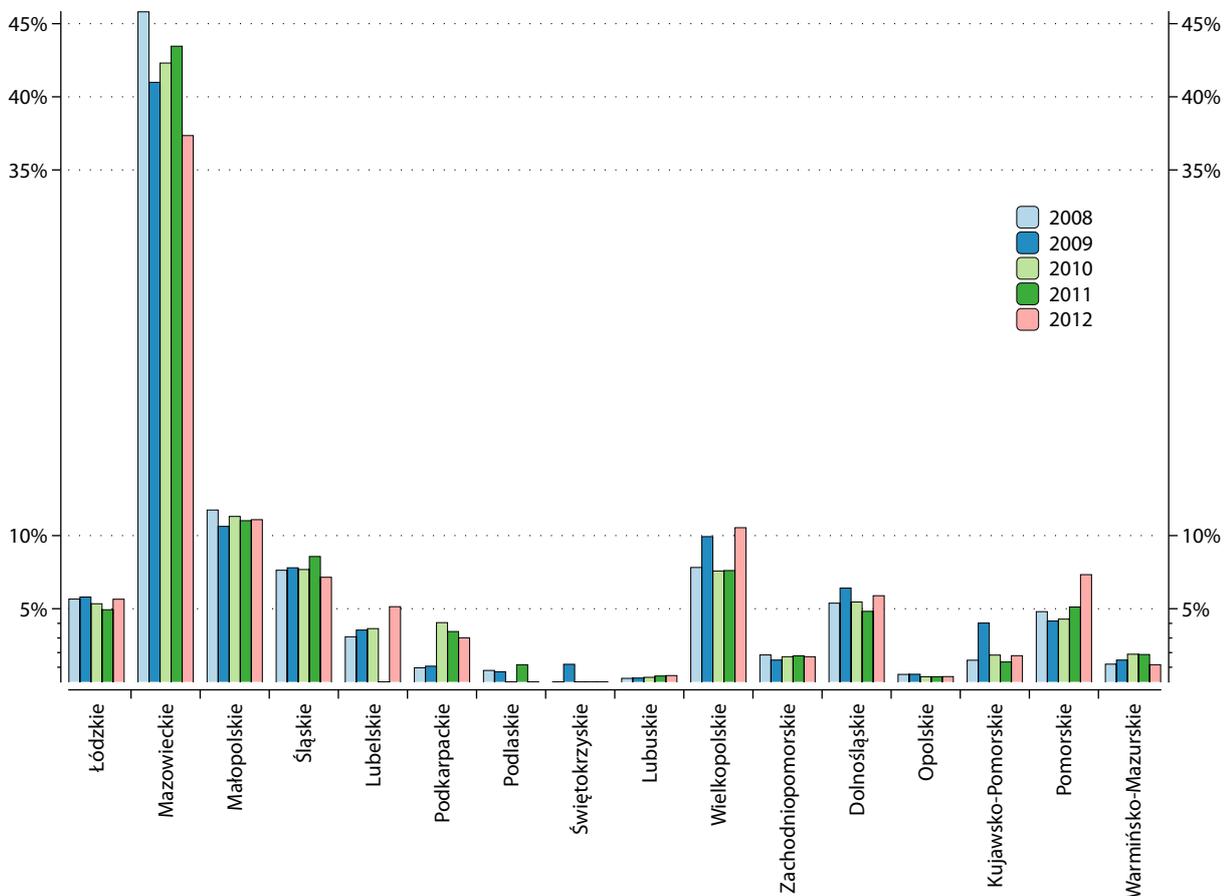
The examinations of intramural expenditures average on R&D by fields of science highlight the discrepancy between Poland's voivodships in 2008–2012 (fig. 3).

3. [In the journal (in both Polish and English texts) European practice of number notation is followed—for example, 36 333,33 (European style) = 36 333.33 (Canadian style) = 36,333.33 (US and British style). Furthermore in the International System of Units (SI units), fixed spaces rather than commas are used to mark off groups of three digits, both to the left and to the right of the decimal point.—Ed.]



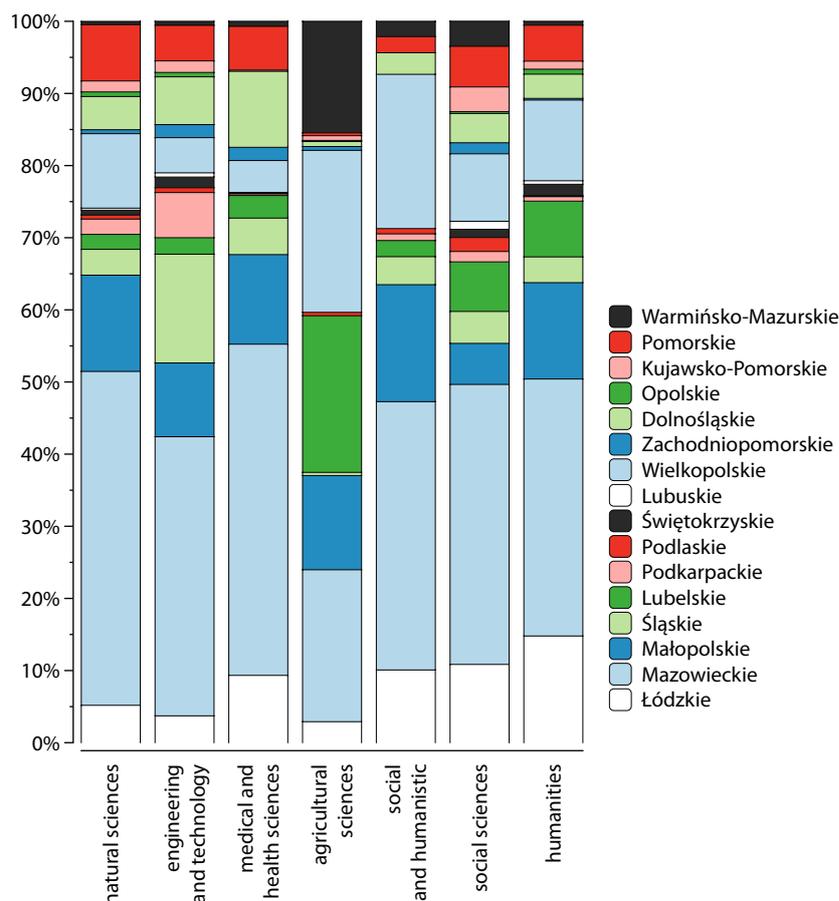
**Fig. 1.** The presentation of intramural expenditures on R&D by NACE 2007 sections B, C, D and E in Poland's voivodships in 2008–2012

Source: own calculations based on data published by the Central Statistical Office of Poland at <http://stat.gov.pl/bdl/>, [accessed 2014.06.27].



**Fig. 2.** The presentation of intramural expenditures on R&D by NACE 2007 sections other than industries in Poland's voivodships in 2008–2012

Source: own calculations based on data published by the Central Statistical Office of Poland at <http://stat.gov.pl/bdl/>, [accessed 2014.06.27].



**Fig. 3.** The presentation of intramural expenditures average on R&D by fields of science in Poland's voivodships in 2008–2012

*Source:* own calculations based on data published by the Central Statistical Office of Poland at <http://stat.gov.pl/bdl/>, [accessed 2014.06.27]

The analysis indicates that the relatively sublime direction of intramural expenditures on R&D is related to social science (on average more than 3,76% in half of the voivodships) as well to engineering and technology (on average more than 3,00% in half of the voivodships). Afterwards followed natural science (on average more than 2,10% in half of the voivodships), humanities (on average more than 2,47% in half of the voivodships), medical and health sciences (on average more than 2,48% in half of the voivodships), social and humanistic (on average more than 2,18% in half of the voivodships) and agricultural sciences (on average more than 0,59% in half of the voivodships). The above distribution of intramural expenditures on R&D points out the demand for development with application in particular scientific directions. Moreover, the significant discrepancy should be emphasised between Poland's voivodships in the scientific directions of intramural expenditures on R&D. That might be explained by the internal requirement depicting the nature of a specific voivodship.

#### 4 The cluster analysis of Poland's voivodship R&D expenditures

The results of the research provide the conclusion that Poland's voivodships were diversified in R&D expenditures in the period of 2008–2012. Taking into account the accepted variables, the slightest similarity in R&D expenditures appeared between Mazowieckie (NUTS PL12) (2) and Małopolskie voivodships (NUTS PL 21) (3) (tab. 1).

The obtained outcomes, achieved by cluster analysis application, indicate that though Małopolskie Voivodship (NUTS PL 21) engages several operations in improving innovation level and regional competitiveness, the distance to the leader in R&D expenditures—Mazowieckie (NUTS PL12) (2) is significant, especially in an average of intramural expenditures on R&D in the business

**Tab. 1.** Matrix of distance clusters of R&D expenditures between Poland's voivodships

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0,00	7,88	1,86	1,60	0,53	0,70	1,14	1,41	1,68	0,89	1,15	1,08	1,33	0,74	1,10	1,14
2	7,88	0,00	6,60	6,73	8,34	7,98	8,86	9,12	9,37	7,11	8,93	7,10	9,05	8,44	7,35	8,92
3	1,86	6,60	0,00	1,80	2,25	2,08	2,71	3,19	3,43	1,17	2,86	0,96	2,99	2,36	0,96	2,86
4	1,60	6,73	1,80	0,00	2,03	1,66	2,48	2,64	2,84	1,12	2,48	1,17	2,58	2,04	1,67	2,49
5	0,53	8,34	2,25	2,03	0,00	0,69	0,65	0,99	1,24	1,38	0,66	1,49	0,85	0,41	1,37	0,65
6	0,70	7,98	2,08	1,66	0,69	0,00	1,13	1,24	1,51	1,31	1,09	1,32	1,23	0,87	1,23	1,06
7	1,14	8,86	2,71	2,48	0,65	1,13	0,00	0,84	0,89	1,91	0,35	1,93	0,36	0,47	1,78	0,39
8	1,41	9,12	3,19	2,64	0,99	1,24	0,84	0,00	0,38	2,28	0,50	2,38	0,58	1,02	2,29	0,46
9	1,68	9,37	3,43	2,84	1,24	1,51	0,89	0,38	0,00	2,52	0,62	2,60	0,54	1,15	2,52	0,62
10	0,89	7,11	1,17	1,12	1,38	1,31	1,91	2,28	2,52	0,00	1,99	0,46	2,14	1,47	0,87	1,99
11	1,15	8,93	2,86	2,48	0,66	1,09	0,35	0,50	0,62	1,99	0,00	2,06	0,24	0,59	1,95	0,08
12	1,08	7,10	0,96	1,17	1,49	1,32	1,93	2,38	2,60	0,46	2,06	0,00	2,17	1,52	0,59	2,07
13	1,33	9,05	2,99	2,58	0,85	1,23	0,36	0,58	0,54	2,14	0,24	2,17	0,00	0,68	2,07	0,30
14	0,74	8,44	2,36	2,04	0,41	0,87	0,47	1,02	1,15	1,47	0,59	1,52	0,68	0,00	1,47	0,62
15	1,10	7,35	0,96	1,67	1,37	1,23	1,78	2,29	2,52	0,87	1,95	0,59	2,07	1,47	0,00	1,94
16	1,14	8,92	2,86	2,49	0,65	1,06	0,39	0,46	0,62	1,99	0,08	2,07	0,30	0,62	1,94	0,00

1—Łódzkie (NUTS PL11),

2—Mazowieckie (NUTS PL12),

3—Małopolskie (NUTS PL21),

4—Śląskie (NUTS PL22),

5—Lubelskie (NUTS PL31),

6—Podkarpackie (NUTS PL32),

7—Podlaskie (NUTS PL34),

8—Świętokrzyskie (NUTS PL33),

9—Lubuskie (NUTS PL43),

10—Wielkopolskie (NUTS PL41),

11—Zachodniopomorskie (NUTS PL42),

12—Dolnośląskie (NUTS PL51),

13—Opolskie (NUTS PL52),

14—Kujawsko-Pomorskie (NUTS PL61),

15—Pomorskie (NUTS PL63),

16—Warmińsko-Mazurskie (NUTS PL62).

*Note:* Shaded cells indicate the smallest distance between a pair of voivodships in the R&D expenditures scope (for each column of the matrix)

*Source:* own calculations based on data published by the Central Statistical Office of Poland at <http://stat.gov.pl/bdl/>, [accessed 2014.06.27]

enterprise sector. On the other hand, the calculation indicates a highly close match in R&D expenditures between Zachodniopomorskie (NUTS PL42) (11) and Warmińsko-Mazurskie voivodships (NUTS PL62) (16). These voivodships are distinguished by a very similar number of persons employed in R&D per 1000 economically active persons, entities with research and development activity by sectors of performance, intramural expenditures on R&D per capita, total extramural expenditures<sup>4</sup> on R&D and level of intramural expenditures on R&D in the business enterprise sector. Simultaneously, it has to be emphasized that these voivodships are also distinguished by a relatively low level of R&D expenditures.

4. Extramural expenditures on R&D activity are defined as expenditures on R&D obtained from other domestic and foreign contractors or subcontractors together with contributions and other resources, see: [http://stat.gov.pl/cps/rde/xbcr/wroc/ASSETS\\_Dzialalnosc\\_badawcza\\_i\\_rozwojowa.pdf](http://stat.gov.pl/cps/rde/xbcr/wroc/ASSETS_Dzialalnosc_badawcza_i_rozwojowa.pdf).

Furthermore, the results highlight a comparatively high similarity in R&D expenditures described by the variables between Podlaskie (NUTS PL34) (7) and Zachodniopomorskie voivodships (NUTS PL42) (11), Lubuskie (NUTS PL43) (9) and Świętokrzyskie voivodships (NUTS PL33) (8), Kujawsko-Pomorskie (NUTS PL61) (14) and Lubelskie voivodships (NUTS PL31) (5), Łódzkie (NUTS PL11) (1) and Lubelskie voivodships (NUTS PL31) (5) and between Opolskie (NUTS PL52) (13) and Warmińsko-Mazurskie voivodships (NUTS PL62) (16). In most cases the results indicate a relatively low level of R&D expenditures in these voivodships. Additionally, the results feature a very highly close match in R&D expenditures between Wielkopolskie (NUTS PL41) (10) and Dolnośląskie voivodships (NUTS PL51) (12), but in that case analysis shows a comparatively high level of R&D expenditures, which might result in boosting a region's competitiveness position.

## Conclusions

The research leads to several conclusions. In the first instance, the results indicate the discrepancy in R&D expenditures between Poland's voivodships within the period of 2008–2012. The results proved that the Eastern and South-western regions of Poland are distinguished by a relatively low level of intramural expenditures on R&D in sections connected with industry. This might arise from difficulties with internal resources essential for R&D activity. In this situation it is advisable to increase the level of external resource acquisition, which might enhance knowledge transfer and innovation. That situation might contribute to increasing competitiveness of a particular region. Additionally, the research results allow the conclusion that these regions of Poland feature the same relationship in intramural expenditures on R&D by NACE 2007 sections other than that of industries.

This analysis leads to the conclusion that Central and North-western regions of Poland are characterized by a larger level of intramural expenditures on R&D in sections other than industries than in industrial sections. Simultaneously, it is worth pointing out that in 2008–2012 these regions featured similar tendencies of R&D expenditures in all sections by NACE 2007 categories. That occurrence might testify to the similar development of every section. This situation should be treated as positive.

Furthermore, the results of the research highlight different directions of intramural expenditures on R&D between Poland's voivodships, which might arise from internal requirements of particular regions. Moreover, taking into account persons employed in R&D per 1000 economically active persons, units with research and development activity by sectors of performance, intramural expenditures on R&D per capita, extramural expenditures on R&D and intramural expenditures on R&D in the business enterprise sector the analysis show diversity in R&D expenditures area between Poland's voivodships.

The results indicate the necessity for opening up Poland's voivodships to knowledge transfer, which would allow them to increase their expenditures on R&D and, in consequence, increase their innovation spectrum. It is necessary to engage operations, especially on a microeconomic scale, which encourage companies to take actions for R&D development.

The complexity of R&D expenditure issues require further studies. They should be concentrated particularly on identification of the determinants which might drive R&D activity.

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