DIVERSIFICATION OF ENTERPRISE INNOVATION ACTIVITY LEVEL VS. GROSS DOMESTIC PRODUCT LEVEL PER CAPITA IN POLISH REGIONS

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Abstract

The research of innovation activities in Polish regions was carried out taking into account both the scale of expenditure incurred by enterprises (input indicators) and the achieved results in the form of e.g. income earned for selling innovation products (output indicators). The purpose of the study is to identify the diversification of innovation activity level, as well as the analysis and assessment of changes over time. The assessment also covered mutual relationships occurring between the level of innovation activities and GDP per capita in Polish regions. The method of multivariate comparative analysis with particular emphasis on aggregate measures of development and econometric methods were applied in empirical studies. The research covered 16 Polish regions in the years 2006 and 2014.

Key words: innovation activities, aggregate measures of development, Polish regions

JEL Code: O30, O18, C40

Introduction

Smart development represents one of the priorities of Europe 2020 strategy, which focus on the development of knowledge-based economy and innovation. Supporting innovation oriented activities also remains one of the main goals of Polish economic policy and is considered the determinant of contemporary socio-economic development. Innovation is approached as the driving force of future growth, therefore one of the crucial strategic objectives is to provide incentives for innovation activities at both national and regional level (Bishop, 2008).

Innovation is analysed as the development factor in many modern theories of regional growth, e.g. production cycle (Grosse, 2002), flexible production (Storper, 1997), new growth

theory, new economic geography (Martin and Sunley, 1996), a primary product (Andrews, 1953), territorial production systems and a learning region (Florida, 1995), (Głuszczuk, 2015).

The Oslo Manual defines innovation activities as *"all scientific, technical, organizational, financial and commercial steps which actually lead, or are intended to lead to the implementation of innovations"* (OECD/European Communities, 2005), (Echeverria, 2008). Innovation activities can be approached based on the aspect of expenditure and their effects. It results in distinguishing two types of indicators for innovation activities in enterprises: input, referring to all types of spending covered in relation to carrying out innovation projects and output, identifying innovation companies based on their results achieved from selling innovation products (Shypulina, 2015), (Teece, 2010).

Innovation activity is not evenly distributed, therefore the presented study attempts to identify the diversity of Polish regions in terms of innovation activities performed by enterprises and the quantification of impacts exerted by innovating enterprises on the regional economic potential measured by GDP *per capita*.

1 Information background and research methodology

The statistical information, indispensable in identifying and quantifying enterprise innovation activity level and its impact on GDP *per capita*, in the cross-section of Polish NUTS 2 regions, were collected from the Local Data Bank (LDB), the largest Polish database about innovations, and also from the Eurostat databases. The analysis covered 16 Polish NUTS 2 regions. The period of research refers to the years 2006 and 2014. The empirical analysis was conducted in accordance with the following research procedure stages:

1. The selection of indicators describing innovation activities of enterprises.
2. Linear ordering of NUTS 2 regions in terms of input, output and total innovation activity level in enterprises.
3. The assessment of input, output and total enterprise innovation level diversification in Polish regions using basic descriptive parameters in the years 2006 and 2014.
4. The classification of Polish NUTS 2 regions in terms of total enterprise innovation activity level in the years 2006 and 2014.
5. The identification of total innovation activity level impact on GDP *per capita* in the years 2006 and 2014 using regression analysis.

The following indicators were applied in the assessment of input enterprise innovation activity level in Polish regions: X_1 – share of expenditure on innovations in enterprises in domestic expenditure (%), X_2 – expenditure on innovations in enterprises per one professionally active person (PLN), X_3 – enterprises which incurred expenditure on innovations (industrial sector) (%), X_4 – enterprises which incurred expenditure on innovations (service sector) (%).

The identification of output innovation activity level in enterprises was conducted using the below presented indicators: X_5 – sold production share of new/significantly improved products in industrial enterprises in the total value of sold goods (%), X_6 – average share of innovating enterprises in the total number of enterprises (%), X_7 – share of net sales income on products manufactured by high and mid-high tech enterprises (%).

Total innovation activities carried out by enterprises was identified based on $X_1 - X_7$ indicators.

Zero unitarization method (Kukuła, 2000) was applied for the normalization of innovation activity identifiers. Due to the fact that all identified innovation factors play the role of stimulants, the normalization formula takes the following form:

$$z_{ij} = \frac{x_{ij} - \min\limits_i x_{ij}}{\max\limits_i x_{ij} - \min\limits_i x_{ij}} \qquad (1)$$

z_{ij} – normalized value of j-th indicator in i-th object-region, x_{ij} – value of j- th indicator in i-th object-region.

Average standardized sums method was applied as the function aggregating normalized values of diagnostic characteristics:

$$SMk_n = \frac{1}{m}\sum_{j=1}^{m} z_{ij} \qquad (2)$$

m – the number of indicators describing a complex phenomenon, n = 1, 2,…, N object-region number , k – type of innovation activity ($input$, $output$, AI), where: $SMinput_n$, $SMoutput_n$, $SMAI_n$ – the respective aggregate measures of input, output and total enterprise innovation activity level.

The identifies of enterprise innovation activity level, normalized using zero unitarization method, take values in [0, 1] interval, therefore aggregate measures for the particular types of innovation activities are characterized by the following value:

$$SMinput_n, SMoutput_n, SMAI_n \in [0,1] \qquad (3)$$

The division of Polish regions into groups, characterized by different total enterprise innovation activity is suggested by specifying the following intervals of aggregate measure values:
group I – regions characterized by the low level of total enterprise innovation activity:

$$SMAI_n \leq \min_n \{SMAI_n\} + \frac{1}{3}R \qquad (4)$$

group II – regions characterized by the average level of total enterprise innovation activity:

$$\min_n \{SMAI_n\} + \frac{1}{3}R < SMAI_n \leq \min_n \{SMAI_n\} + \frac{2}{3}R \qquad (5)$$

group III – regions characterized by the high level of total enterprise innovation activity:

$$\min_n \{SMAI_n\} + \frac{2}{3}R < SMAI_n \leq 1 \qquad (6)$$

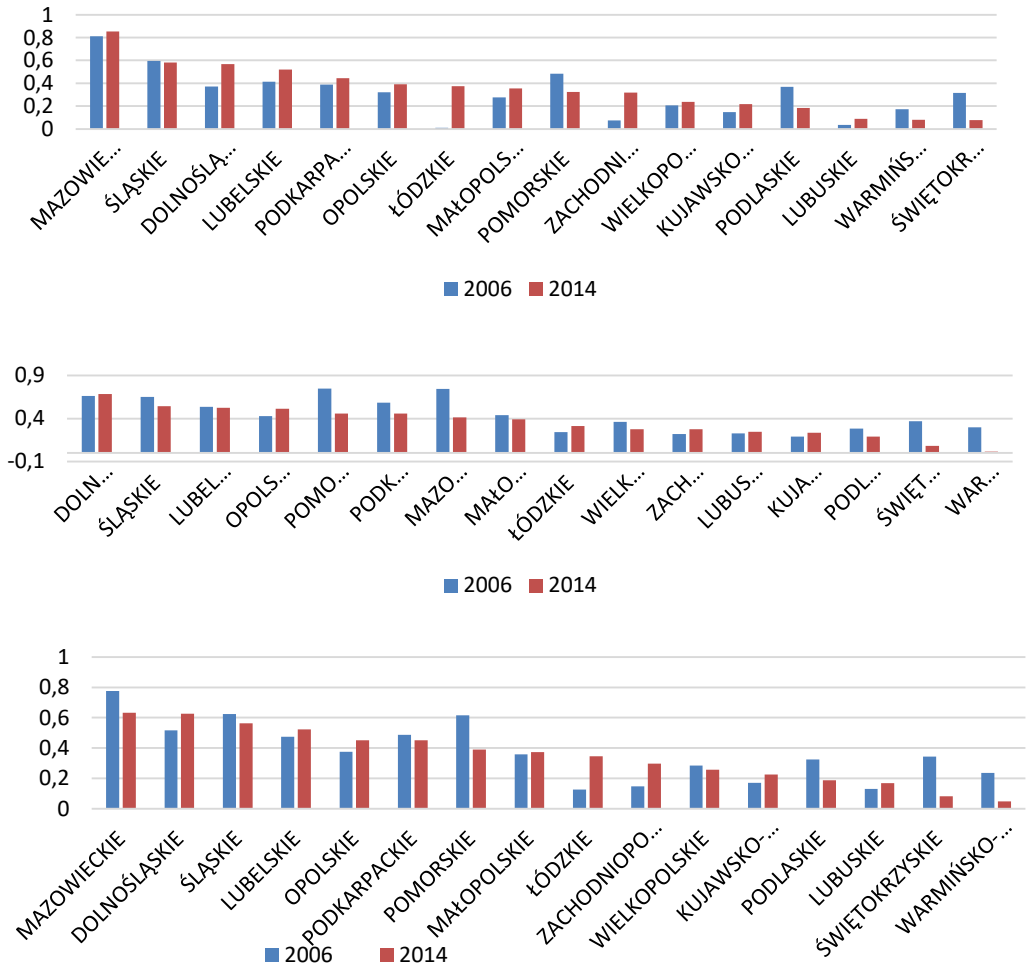
where: R – aggregate value range measuring the development of a complex phenomenon.

The assessment of total enterprise innovation activity level on GDP *per capita* was conducted using descriptive econometric models with one explanatory variable. Heuristic method was used to identify the analytical form of econometric models. The best analytical from of the model, from the perspective of model adjustment to empirical data (maximum value of R^2 coefficient of determination) was selected among the following functions: linear, multivariate, power, exponential and logarithmic one.

2 Empirical research results

Figure 1 presents linear ordering of Polish regions in the years 2006 and 2014 in terms of input, output and total innovation activity of enterprises. The regions were ordered by the decreasing values of particular aggregate measures in 2014. As it can be observed, by far the highest level of input innovation activity, in both analysed periods, was recorded in Mazowieckie region, to be followed by Śląskie region. Mazowieckie region, in both studied years, had the highest values of input indicators: share of expenditure on innovation activities in enterprises against domestic expenditure (38,9% in 2006 and 33,3% in 2014) and expenditure on innovation activities in enterprises per one professionally active person (about PLN 4064 in 2006 and PLN 4436 in 2014). Śląskie region was characterized by the relatively high values of all input innovation activities.

Fig. 1: Linear ordering of aggregate measure values of input (*SMinput*), output (*Smoutput*), total (*SMAI*) enterprise innovation activity levels



Source: authors' compilation based on LDB and Eurostat databases.

The lowest level of innovation activities, carried out by enterprises in 2006, was observed in Łódzkie and Lubuskie regions, whereas in 2014 in Świętokrzystkie and Warmińsko-Mazurskie. In 2006 the values of three out of four innovation activity indicators were, by far, the lowest among all regions: expenditure on innovations in enterprises per 1 professionally active person (PLN 472,48), share of industrial sector enterprises, which incurred expenditure on innovation activities (PLN 13,64%) and share of service sector enterprises, which incurred expenditure on innovation activities (11,26%). In 2006 Lubuskie region recorded the lowest share of spending on enterprise innovations in domestic expenditure (1%). In 2014 Świętkorzyskie region recorded the lowest values of three out of four input innovation indicators in the group of 16 regions, i.e.: share of expenditure on enterprise innovation activities in domestic expenditure (0,7%),

enterprise innovations in domestic expenditure (1%), expenditure on innovations in enterprises per 1 professionally active person (PLN 381,15), share of innovating enterprises in the industrial sector (9,48%).

In 2006 Pomorskie and Mazowieckie regions were characterized by the definitely highest level of output innovation activity. In Pomorskie region the most favourable values, comparing to all regions, were recorded for: the share of sold production of new/significantly improved products in industrial enterprises in the total value of sold goods (33,5%) and the average share of innovating enterprises in the total number of enterprises (26,25%). In 2006 the lowest innovation activity of enterprises was observed in Kujawsko-Pomorskie and Zachodniopomorskie regions. In 2014 the highest output innovation activity was characteristic for Dolnośląskie and Śląskie regions, whereas the lowest one, similarly to input innovation activity, for Warmińsko-Mazurskie and Świetokrzyskie regions. In 2006 the highest total innovation activity was recorded in Mazowieckie and Pomorskie regions, and the lowest in Łódzkie and Lubuskie. In 2014 Mazowieckie and Dolnośląskie regions were in the lead, while the lowest innovation activity level was observed in Warmińsko-Mazurskie and Świetokrzyskie regions.

Table 1 presents the descriptive parameters of aggregate measures for input, output and total enterprise innovation activity level in both studied periods.

Tab. 1: Descriptive parameters of aggregate measures for enterprise innovation activity level in Polish regions in the years 2006 and 2014

Descriptive parameters	2006			2014		
	SMinput	*SMoutput*	*SMAI*	*SMinput*	*SMoutput*	*SMAI*
Minimum	0,01	0,19	0,13	0,08	0,01	0,05
Maximum	0,81	0,75	0,78	0,85	0,68	0,63
Range	0,80	0,55	0,65	0,78	0,67	0,59
Mean	0,31	0,44	0,37	0,35	0,35	0,35
Median	0,32	0,40	0,35	0,34	0,35	0,36
Variation coefficient (%)	67,52	44,19	52,08	60,18	50,76	52,16
Skewness coefficient	-0,10	0,60	0,36	0,17	-0,02	-0,13

where: *SMinput, SMoutput, SMAI* – aggregate measure of input, output and total enterprise innovation activity

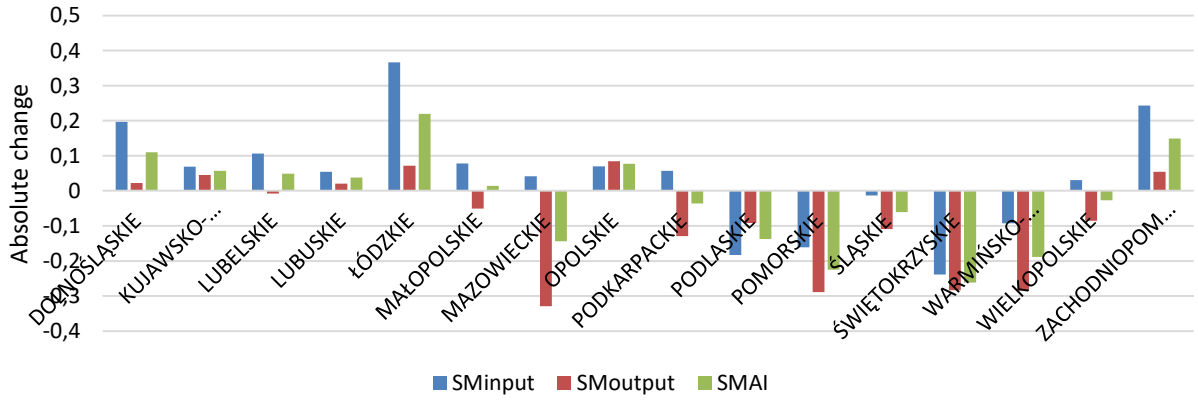
Source: authors' calculations based on LDB and Eurostat databases.

The definitely highest diversification in both 2006 and 2014 was characteristic for Polish regions in terms of input innovation activity level, however, this diversification has significantly decreased. The coefficient of variation of aggregate measures *SMinput* presented the following respective values in 2006 and 2014: 67,52% and 60,18%. Regional diversification in terms of output innovation activity was the lowest, but it went up from the level of 44,19% in 2006 to

50,76% in 2014. The dispersion of regions regarding total innovation activity in both studied periods reached the level of approx. 52%. The distribution of aggregate measures was characterized by significant positive asymmetry in 2006 in case of output innovation activity level (0,60) and the total one (0,36), which means that the dominating regions were characterized by lower than average innovation activity.

Fig. 2 presents absolute changes of aggregate measures for input, output and total enterprise innovation activity, recorded in 2014 against 2006. 11 Polish regions were characterized by the increase of input innovation activity, whereas the largest one took place in Łódzkie, Zachodniopomorskie and Dolnośląskie regions. The largest drop in input innovation activity was true for Świętokrzyskie and Podlaskie regions. In case of 6 regions only a slight upward trend of output innovation activity was observed, along with a significant drop in the remaining regions with the largest one occurring in Mazowieckie, Pomorskie, Świętokrzyskie and Warmińsko-Mazurskie. Łódzkie region was characterized by the largest total innovation activity growth, whereas Świętokrzystkie and Pomorskie regions by the largest decline of this indicator.

Fig. 2: Absolute changes of aggregate measure values for input, output and total innovation activity in the years 2006 and 2014



Source: authors' compilation based on LDB and Eurostat databases.

Table 2 presents the division of regions into classes in terms of total innovation activity level. As it can be observed, 3 equal groups of regions were distinguished in both analysed years. The smallest group covers the regions presenting high activity level of enterprises and in 2006 it included Mazowieckie, Śląskie and Pomorskie regions, whereas in 2014 Mazowieckie, Dolnosląskie and Śląskie regions. The largest group listed 7 regions presenting the average innovation activity level in each of the years. The distribution of aggregate measures was

characterized by significant positive asymmetry in 2006 in case of output innovation activity level (0,60) and the total one (0,36), which means that the dominating regions were characterized by lower than average innovation activity.

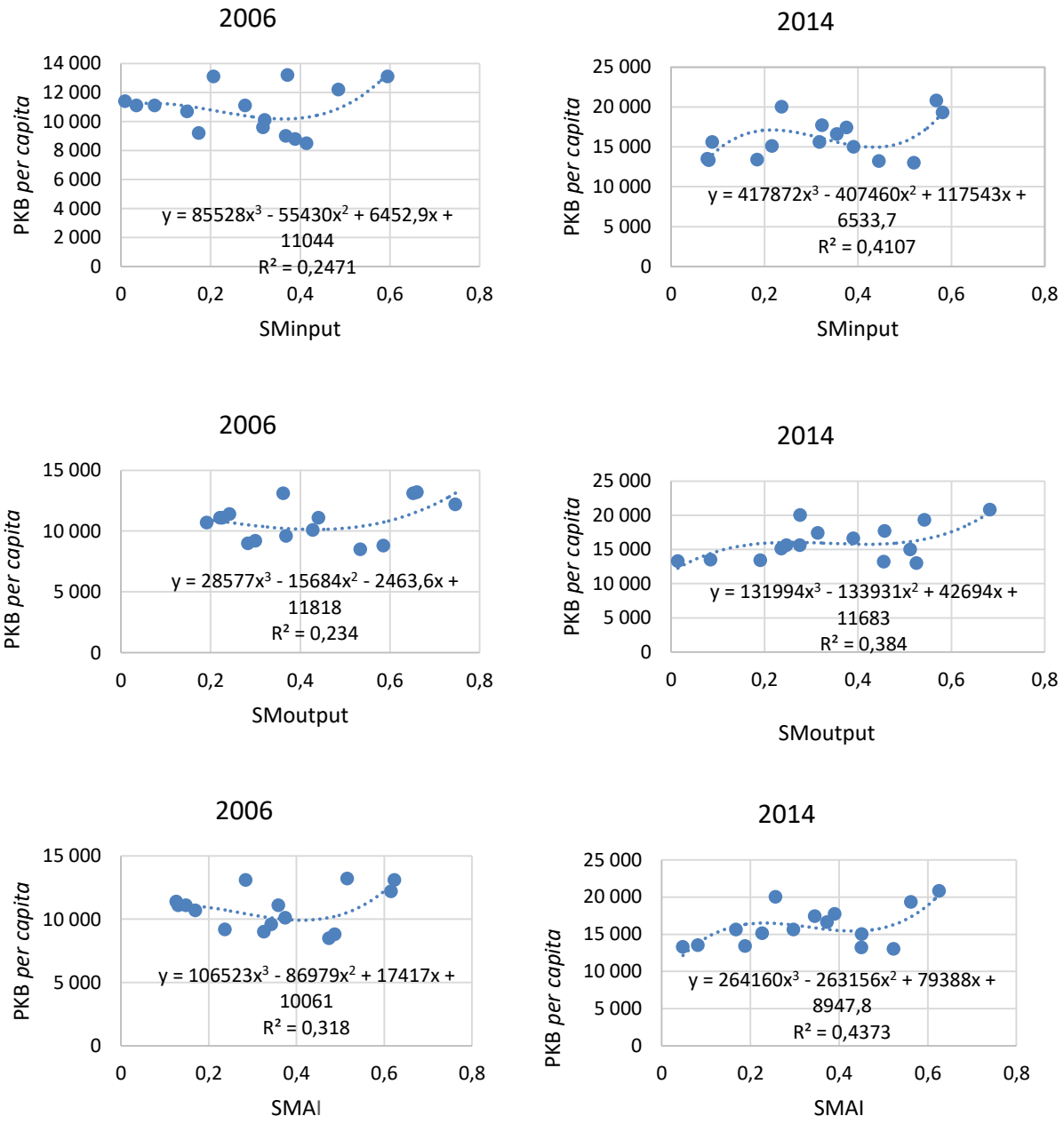
Tab. 2: The classification of Polish regions in terms of total innovation level in the years 2006 and 2014

Total innovation activity level	Years			
	2006		2014	
	Region	SMAI value	Region	SMAI value
High	Mazowieckie	0,7764	Mazowieckie	0,6330
	Śląskie	0,6234	Dolnośląskie	0,6254
	Pomorskie	0,6154	Śląskie	0,5624
Average	Dolnośląskie	0,5157	Lubelskie	0,5231
	Podkarpackie	0,4868	Opolskie	0,4514
	Lubelskie	0,4739	Podkarpackie	0,4504
	Opolskie	0,3743	Pomorskie	0,3904
	Małopolskie	0,3588	Małopolskie	0,3727
	Świętokrzyskie	0,3426	Łódzkie	0,3450
	Podlaskie	0,3255	Zachodniopomorskie	0,2968
Low	Wielkopolskie	0,2841	Wielkopolskie	0,2568
	Warmińsko-Mazurskie	0,2365	Kujawsko-Pomorskie	0,2263
	Kujawsko-Pomorskie	0,1695	Podlaskie	0,1879
	Zachodniopomorskie	0,1480	Lubuskie	0,1678
	Lubuskie	0,1304	Świętokrzyskie	0,0814
	Łódzkie	0,1257	Warmińsko-Mazurskie	0,0478

Source: authors' calculations based on LDB and Eurostat databases.

Fig. 3 illustrates interdependencies occurring between the level of input, output and total innovation activity level and the level of GDP *per capita*. Due to the fact that Mazowieckie region was characterized by unusual, definitely the highest economic potential, it was not taken into account in assessing the impact of particular innovation types on Polish regions' GDP *per capita*. The analysis of figure 3 shows that the relationships occurring between innovation activities and economic potential were insignificant. In all analysed cases they were best reflected by the analytical function of third degree polynomial. It can be noticed that both in 2006 and 2014 the total of innovation activities had the highest, even though insignificant, impact on GDP *per capita* (respectively $R^2 = 0,3180$ and $R^2 = 0,4373$), whereas output innovation activities the lowest (respectively $R^2 = 0,2340$ and $R^2 = 0,3840$). In 2014 a slight increase of all analysed innovation activity types on the economic potential of Polish regions was observed.

Fig. 3: The level of enterprise innovation activity and the level of GDP *per capita* in the years 2006 and 2014



Source: authors' compilation based on LDB and Eurostat databases.

Conclusions

Based on the conducted empirical research it can be concluded that the diversification of enterprise innovation activity in Polish regions in 2006 and 2014 was significant, the variation coefficient exceeded 50%. The exception was the diversification of regions in terms of output innovation activity in 2006 (44,19%). In 2014 the dispersion of regions related to innovation activity was lower, whereas with regard to output innovation activity it went up. The highest total

innovation activity, in both analysed periods, was characterized by Mazowieckie region and the lowest by Łódzkie region in 2006, but in 2014 by Warmińsko-Mazurskie. In the years 2006 and 2014 the innovation activity of enterprises did not exert any substantial impact on GDP *per capita*. This conclusion refers to input, output and the of total innovation activities. It seems founded to extend further empirical research by all NUTS 2 European Union regions and to attempt assessing their diversification in terms of innovation activity and its impact on an economic potential in order to distinguish a reference region.

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