

Sectoral dimension of enterprise innovation in the system of Polish provinces in 2008-2017

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Abstract

The purpose of the article is to conduct a comparative analysis of the results of Polish provinces classification in terms of enterprise innovation in the sectoral dimension, in the years 2008-2017. The assessment covers industry and service sectors, and within these sectors the innovation oriented activity of enterprises. The basic characteristics (available for the analysed period) were used to assess innovation. The classification of Polish provinces, regarding the sectoral dimension of innovation activities in 2008 and 2017 allowed the identification of groups in the borderline years: 4 groups respectively, taking into account the enterprise innovation characteristics in the industry sector as well as 3 and 4 groups of provinces considering the innovation characteristics in the service sector enterprises. To determine the similarities of the obtained classifications and, consequently, to assess and compare the relationship between the analysed sectors in the system of provinces, in terms of the adopted characteristics of enterprise innovation, constituting the research objective of the article, the measure of partition similarity proposed by Sokołowski (1976) was used.

Keywords: Polish provinces, classification, partition similarity, innovativeness

JEL Classification: C38, O18, O31.

1. Introduction

Innovation are consider as (OECD, 2018): “(...) *a new or improved product or process (or a combination thereof) that differs significantly from the unit’s previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)*”. Innovativeness of companies and, in consequence, regions and the country constitutes a significant factor of their development (Grossman and Helpman, 1994; Morgan, 1997; Barkley *et al.*, 2006; Markowska, 2012; Wang *et al.*, 2019). The level of innovativeness of the Polish economy evaluated in annual ranks published by the European Commission (Hollanders *et al.*, 2019a) has not been high for a dozen or so years. Poland along with Croatia, Cyprus, Czechia, Greece, Hungary, Italy, Latvia, Lithuania, Malta, Portugal, Slovakia, Slovenia and Spain is placed in a group of moderate innovators (the index for Poland is substantially below the EU average – and amounts to exactly 56.1% of the average). The Summary

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Innovation Index for Poland in the years 2011-2018 amounted to, respectively: 0.257, 0.242, 0.252, 0.242, 0.248, 0.260, 0.273, and 0.295. The EU average increased from 0.482 to 0.525 during this period. The situation is similar in the ranks of European Union regions, where at the beginning of the last decade Polish regions at the level NUTS 2 were placed in the modest innovator group, apart from the Mazowieckie province (moderate innovator) (Hollanders *et al.*, 2012). According to the 2019 report (Hollanders *et al.*, 2019b), the statistically separated Warsaw region (the capital city of Warsaw along with neighbouring poviats) is the most innovative region in Poland – the only Polish region defined as a *moderate innovator +*. The group of moderate innovators includes the Małopolskie province. Other regions were classified as follows: Śląskie, Wielkopolskie, Dolnośląskie, Pomorskie, Łódzkie and Podkarpackie (*moderate innovator -*); Kujawsko-Pomorskie, Świętokrzyskie, Lubelskie, regional Mazowieckie (*modest innovator +*); Zachodniopomorskie, Lubuskie, Opolskie, Podlaskie and Warmińsko-Mazurskie (*modest innovator*).

Most rankings do not take into consideration whether the data concerns enterprises from the service or industry sector (Markowska and Strahl, 2017). Additionally, there is no research concerning the changes over time, which occur in regard to innovativeness of sectors in the region groups. The purpose of this article is to conduct a benchmarking analysis of the results of classification of provinces in Poland in terms of innovativeness of enterprises in the sectoral dimension in the years 2008-2017. The assessment covers industry and service sectors, as well as innovative activity of enterprises within these sectors.

2. Method

The applied research procedure is presented below as follows:

1. Definition of the set of variables for the purpose of grouping, analyses periods, and research objects.
2. Collection of data and preparation of a complete data matrix, and an initial data analyses.
3. Standardization of variables.
4. Application of the Ward's method (1963).
5. Analysis of the dendrogram to determine the cut-off level.
6. Group membership and variable averages in groups.
7. Evaluation of partition similarity – the measure of partition similarity by Sokołowski (1976).

3. Variables, regions and research period

For assessment and classification purposes, four variables were used, for which comparable statistical data were available in the publications of the Statistics Poland [GUS] as at both borderline dates (Activity, 2011, 2018) in regard to enterprises with a separation of the industry sector and services sector. The list of variables is presented below.

Variables for the industry sector enterprises:

IM_1 – enterprises, which introduced innovations, as a % of the total of industrial enterprises;

IM_2 – spendings per 1 industrial enterprise conducting innovative activity in thous. PLN;

IM_3 – share of revenue from sales of new or significantly improved products in total revenue of industrial enterprises;

IM_4 – enterprises, which incurred expenses on innovative activity, as a % of the total of industrial enterprises.

Variables for the service sector enterprises:

IS_1 – enterprises, which introduced innovations, as a % of the total of service enterprises;

IS_2 – spendings per 1 service enterprise conducting innovative activity in thous. PLN;

IS_3 – share of revenue from sales of new or significantly improved products in total revenue of service enterprises;

IS_4 – enterprises, which incurred expenses on innovative activity, as a % of the total of service enterprises.

The classification of sixteen provinces in Poland, which were the objects of research, was conducted in regard to the above variables in 2008 and in 2017.

4. Results of cluster analysis

The described research procedure (items 1-6) was applied four times (industry sector and service sector in 2008 and in 2017) for the above-mentioned variables. The dendrograms obtained after the application of the Ward's method allowed for a relatively easy identification of the optimum number of groups. The same cut off point was adopted for all four groups, amounting to 10 (Fig. 1, 2). For the industry sector, four groups were obtained in both analysed years, and for the service sector – 3 and 4 groups, respectively.

The average structures for the resulting groups (for the industry sector and for the service sector based on the data from 2008 and 2017) and the composition of groups is presented in Tables 1-4.

Based on the value of variables, which characterize enterprises in the industry sector as of 2008, in the province grouping process the following four groups were obtained (Table 1):

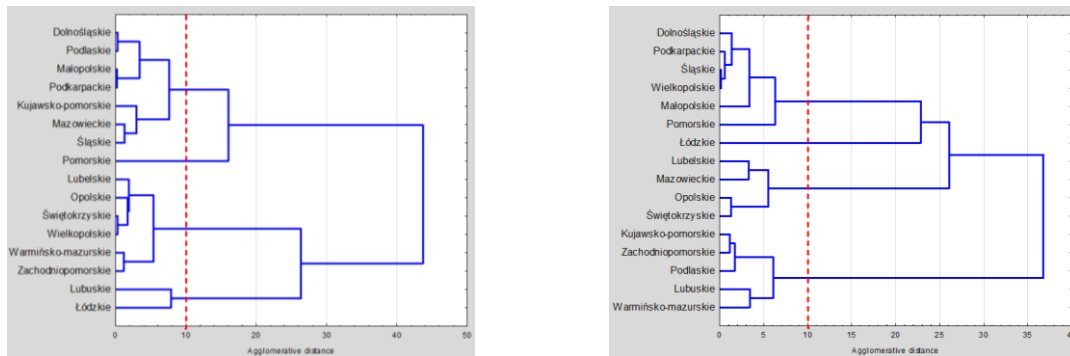


Figure 1. Grouping results – industry sector in 2008 (left) and in 2017 (right).

Table 1. Average variables in groups – industry sector in 2008

Group	Count	Province	IM_1	IM_2	IM_3	IM_4
1	7	Dolnośląskie, Podlaskie, Śląskie, Małopolskie, Podkarpackie, Kujawsko- Pomorskie, Mazowieckie	23.4	4709.4	12.5	18.8
2	1	Pomorskie	25.1	6145.5	27.0	19.1
3	6	Lubelskie, Opolskie, Świętokrzyskie, Wielkopolskie, Warmińsko-Mazurskie, Zachodniopomorskie	19.8	2831.3	9.0	16.0
4	2	Lubuskie, Łódzkie	14.9	6173.5	11.4	10.5

1/ almost highest values of all variables characterize a single-element group, which includes the Pomorskie; 2/ average values in the two-element fourth group are lowest for the following variables: share of enterprises, which introduced innovations, in the general number of industry enterprises, and the percentage of enterprises, which incurred expenses on innovative activity in the total number of industry enterprises, and highest values in the share of revenues from the sales of new or significantly improved products in total revenues of industry enterprises; 3/ the first group (7 provinces) presents the second largest share of revenues from sale of new or significantly improved products in the total revenues of industry enterprises.

The characteristics of groups in terms of similar variables concerning innovativeness of industry enterprises in 2017 are presented below:

Table 2. Average variables in groups – industry sector in 2017

Group	Count	Province	IM_1	IM_2	IM_3	IM_4
1	6	Dolnośląskie, Podkarpackie, Śląskie, Wielkopolskie, Małopolskie, Pomorskie	11.9	5448.2	9.0	15.6
2	1	Łódzkie	10.7	13325.0	6.5	12.2
3	4	Lubelskie, Mazowieckie, Świętokrzyskie, Opolskie	14.5	4599.8	4.7	15.6
4	5	Kujawsko-Pomorskie, Podlaskie, Zachodniopomorskie, Lubuskie, Warmińsko-Mazurskie	10.1	3499.0	5.0	12.7

- largest group, with the highest average share of revenues from sale of new or significantly improved products in total revenue of industry enterprises, and the share of enterprises, which incurred expenses for innovative activity in the total number of industry enterprises;
- one-element group, which includes the Łódzkie, with the highest expenses per an industrial enterprise conducting innovative activity, and the lowest share of enterprise which incurred expenses on innovative activity in the total number of industrial enterprises;
- the highest average share of enterprises, which introduced innovation, and enterprises, which incurred expenses on innovative activity as a percentage of the total industry enterprises and the lowest share of revenues from sales of new or significantly improved products in the total revenues of industry enterprises;
- where the following average variables are the lowest: IM_1, IM_2 and IM_4.

The second group with most provinces received lowest values of average variables, which characterized service sector enterprises in 2008; whereas highest values were obtained for Mazowieckie (one-element group) (Table 3).

In 2017, average values in the largest group (seven provinces) were lowest for every variable, whereas the highest values were obtained for the Mazowieckie, similarly as in previous grouping, thus creating a one-element group in this division (Table 4).

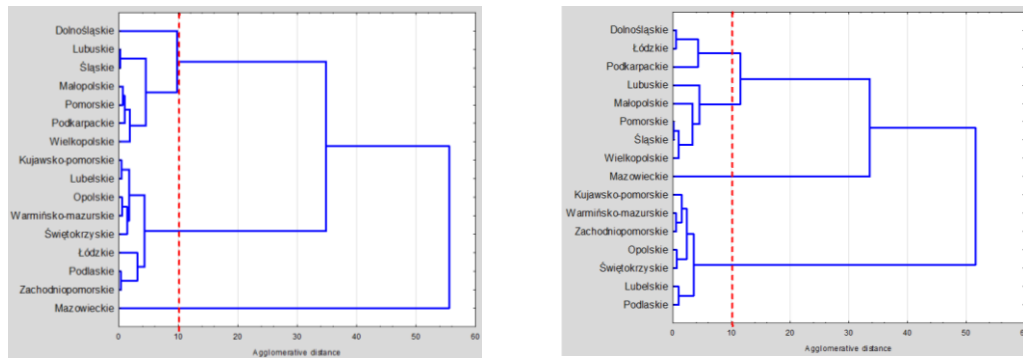


Figure 2. Grouping results – services sector in 2008 (left) and in 2017 (right)

Table 3. Average variables in groups – services sector in 2008

Group	Count	Province	IS_1	IS_2	IS_3	IS_4
1	7	Dolnośląskie, Lubuskie, Wielkopolskie, Małopolskie, Pomorskie, Śląskie, Podkarpackie	16.6	1362.7	3.8	13.1
2	8	Kujawsko-Pomorskie, Lubelskie, Opolskie, Warmińsko-Mazurskie, Świętokrzyskie, Łódzkie, Podlaskie, Zachodniopomorskie	10.8	1362.3	1.3	9.2
3	1	Mazowieckie	22.0	9490.5	8.8	17.9

Table 4. Average variables in groups – services sector in 2017

Group	Count	Province	IS_1	IS_2	IS_3	IS_4
1	3	Dolnośląskie, Łódzkie, Podkarpackie	6.6	1853.0	2.9	8.3
2	5	Lubuskie, Małopolskie, Pomorskie, Śląskie, Wielkopolskie	5.0	2870.2	0.8	8.9
3	1	Mazowieckie	7.1	12194.0	5.5	11.2
4	7	Kujawsko-Pomorskie, Warmińsko- Mazurskie, Zachodniopomorskie, Opolskie, Świętokrzyskie, Lubelskie, Podlaskie	3.1	1264.7	0.6	4.2

5. Partition similarity

The similarity of resulting partitions of provinces in Poland due to innovativeness of enterprises in the sector of industry and services in 2008 and 2017 was evaluated in account of the measure according to the concept proposed by Sokołowski (1976) – Table 5.

Table 5. Measures of partition similarities

Specification	Industry 2008	Industry 2017	Services 2008	Services 2017
Industry 2008	1	0.617	0.567	0.625
Industry 2017	0.617	1	0.733	0.725
Services 2008	0.567	0.733	1	0.842
Services 2017	0.625	0.725	0.842	1

Table 6. Discrimination ability of variables – classical analysis of the variance and non-parametric analysis of the variance (p-values from Kruskal-Wallis test)

Variable	2008	2017	2008	2017
	Classical		Non-parametric	
IM_1	0.0003	0.0006	0.0178	0.0049
IM_2	0.0617	0.0006	0.0656	0.2524
IM_3	0.0006	0.0024	0.1366	0.0193
IM_4	0.0000	0.0035	0.0082	0.0026
IS_1	0.0002	0.0004	0.0080	0.0061
IS_2	0.0000	0.0002	0.0585	0.1720
IS_3	0.0020	0.0000	0.0105	0.0324
IS_4	0.0000	0.0006	0.0188	0.0101

Effects marked in red are significant with $p < 0.0500$.

The conducted research assessed the similarity of resulting groups of provinces in Poland classified due to innovativeness of enterprises in the industry and services sectors. The assessment was made in terms of sectors and years. The largest similarity of partitions (0.842) occurred in provinces grouped in terms of innovativeness of enterprises in the sector of services in 2008 and 2017, and provinces grouped in 2017 in terms of innovativeness of enterprises in the analysed sectors (0.733). The value of this measure falls between 0-1 and even the lowest resulting value (0.567), which concerns the comparison of the partition of provinces (analysed sectors) in 2008 is high enough to state that all resulting grouping pairs are similar. This means that if innovativeness of enterprises (industry and services sectors) changed in the evaluated period, then it changed within the group of provinces. The final results of the research can be summarised in table form – see Tables 6 and 7.

Table 7. Assignment of provinces to groups

Province	Industry		Services	
	2008	2017	2008	2017
Dolnośląskie	1	1	1	1
Podkarpackie	1	1	1	1
Małopolskie	1	1	1	2
Śląskie	1	1	1	2
Kujawsko-pomorskie	1	4	2	4
Podlaskie	1	4	2	4
Warmińsko-mazurskie	3	4	2	4
Zachodniopomorskie	3	4	2	4
Opolskie	3	3	2	4
Świętokrzyskie	3	3	2	4
Lubelskie	3	3	2	4
Łódzkie	4	2	2	1
Lubuskie	4	4	1	2
Pomorskie	2	1	1	2
Wielkopolskie	3	1	1	2
Mazowieckie	1	3	3	3

6. Conclusions

The most important conclusions of the analysis of co-relations of variables include the fact that there is a significant statistical dependency amongst, for example: values of variables concerning innovativeness of enterprises in the industry sector in 2008 and 2017; the levels of variables, which describe innovativeness of enterprises in the services sector in 2008 and 2017; expenses per one enterprises, which conducts innovative activity in thous. PLN in industry enterprises (and 2008 and 2017), in the industry and services sectors (in 2008), and in the services sector (in 2008 and in 2017). The weaker discrimination ability of certain characteristics (mainly IM_2) may partially result from the fact that in 2008 two groups have a very similar average, and from the fact of presence of groups that include only one or two objects – then, the power of variance tests is not too significant (Table 6).

The most “characteristic” similarities in partitions include (see Table 7):

- (1) for groups separated due to the attributes of innovativeness of industry enterprises:
 - four provinces: Dolnośląskie and Podkarpackie as well as Małopolskie and Śląskie, which were in the same group in 2008 and 2017 – three provinces (Opolskie, Świętokrzyskie and Lubelskie) were in the third group in 2008 and in 2017;
 - two provinces in 2008 and in 2017 were together in the following groups: in the first group in 2008, in the fourth group in 2017 (Kujawsko-Pomorskie and Podlaskie), in the third group in 2008, and in the fourth group in 2017 (Warmińsko-Mazurskie and Zachodniopomorskie);
- (2) for groups separated due to the attributes of innovativeness of enterprises in the services sector:
 - seven of the same provinces (Kujawsko-Pomorskie, Podlaskie, Warmińsko-Mazurskie and Zachodniopomorskie as well as Opolskie, Świętokrzyskie and Lubelskie) made the second group in 2008, and the fourth group in 2017;
 - five other provinces (Małopolskie, Śląskie, Lubuskie, Pomorskie and Wielkopolskie) made the first group in 2008, and the second group in 2017;
 - two provinces – Dolnośląskie and Podkarpackie both in 2008 and in 2017 were in one group (first group).

It should be noted that there are four pairs of provinces (1/ Dolnośląskie and Podkarpackie, 2/ Małopolskie and Śląskie, 3/ Kujawsko-Pomorskie and Podlaskie, 4/ Warmińsko-Mazurskie and Zachodniopomorskie) and a group of three provinces (Opolskie, Świętokrzyskie and Lubelskie), which were together in the same groups within the resulting partitions.

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