



## ORIGINAL ARTICLE


**Citation:** Nowak, P. (2021). Cooperation of enterprises in innovative activities on the example of Polish regions. *Equilibrium. Quarterly Journal of Economics and Economic Policy*, 16(4), 839–857. doi: 10.24136/eq.2021.031

Contact: pnowak@tu.kielce.pl

Article history: Received: 13.05.2021; Accepted: 15.10.2021; Published online: 10.12.2021

**Paulina Nowak**

*Kielce University of Technology, Poland*

 [orcid.org/0000-0002-0461-8559](https://orcid.org/0000-0002-0461-8559)

## Cooperation of enterprises in innovative activities on the example of Polish regions

**JEL Classification:** O18; O31

**Keywords:** *innovation activities; cluster analysis; cooperation of enterprises; Polish voivodeships; regional differentiation; Ward's method*

### Abstract

**Research background:** Cooperation is an indispensable element of innovation activities of enterprises. Undertakings in innovation, by nature, require not only significant expenditures or creative human capital, but also cooperation with other enterprises, scientific institutions, and the business environment. Cooperating companies have a greater chance to compete in the international arena while building the innovative potential of the regional environment. Stimulating the permanent cooperation of enterprises operating in the region, in its various forms, is a key challenge for central government authorities, local government authorities, and other actors in social and economic life. The existing literature on the cooperation of enterprises focuses on the motives of cooperation and their effects, but to a lesser extent on the spatial similarity of these processes, i.e. in individual regions of the country.

**Purpose of the article:** The purpose of the article is to diagnose and evaluate regional differences in the level of cooperation between companies conducting innovation activities in Poland. The study used data on innovation activities published by Statistics Poland and data on enterprises participating in cluster cooperation published by the Polish Agency for Enterprise Development.

**Methods:** The cluster analysis was used, allowing to identify voivodeships that are similar to each other in terms of the analyzed phenomenon. The spatial classification of voivodeships was performed using the Ward method, which is classified as hierarchical and is often used to group objects. The result is a hierarchical tree that groups the regions in increasingly larger clusters.

**Findings & value added:** The results indicate a low level of cooperation and the existence of significant differences in the cooperation of enterprises as part of innovation activities in Polish regions. The low level of cooperation between companies in individual regions corresponds to the

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number of marketed innovations. There are similarities between some regions in terms of cooperation on innovation activities. The results of the analysis may provide an indication for national and European Union economic policy entities in the field of creating instruments to support the cooperation of companies on innovation activities.

## **Introduction**

Cooperation is an indispensable element of innovation activities of enterprises. Undertakings in innovation, by nature, require not only significant expenditures and creative human capital but also cooperation with other enterprises, scientific institutions, and the business environment. Cooperating companies have a greater chance to compete in the international arena while building the innovative potential of the regional environment. The existing literature on the cooperation of enterprises focuses on the motives of cooperation and their effects, but to a lesser extent on the spatial similarity of these processes, i.e. in individual regions of the country. Taking into account the assumptions of the innovation policy of Poland and the European Union, which assume an increase in the innovativeness of the economy through, among others, cooperation, compels to question the state and quality of cooperation between Polish companies. Stimulating permanent cooperation between regional companies in its various forms is a key challenge for central and local authorities. Therefore, it is important to get to know the essence of the cooperation of enterprises in the scope of innovation activities.

The purpose of the study is to diagnose and evaluate regional differences in the level of cooperation of enterprises conducting innovation activities. The study used data on innovation activities published by Statistics Poland and Polish Agency for Enterprise Development on cluster cooperation of enterprises.

The cluster analysis was used, allowing to identify voivodeships that are similar to each other in terms of the analyzed phenomenon. The spatial classification of voivodeships was performed using the Ward's method, which is classified as hierarchical and is often used to group objects. The result is a hierarchical tree that groups the regions in increasingly larger clusters.

The study begins with a literature review on the broadly understood cooperation of enterprises with partner institutions. The review concerns the enterprises' innovation activities of scientific, technical, financial, organizational, and commercial nature, aimed at introducing innovations. The part concerning the research methodology presents the essence of cluster analysis as a taxonomic method, which takes into account intra-group variability

and allows us to combine similar objects. The next part presents the results of the analysis of the cooperation of enterprises in the spatial aspect. Cooperation on innovation activities of industrial and service enterprises is included here based on available public statistics. Special attention was paid to the differences in the level of cooperation in innovation activities in Polish voivodeships. The assessment of the level of cooperation between enterprises is complemented by a confrontation with similar studies. The whole study is completed with conclusions from the analysis.

## **Literature review**

Competition is a phenomenon rooted in socio-economic life, as it stimulates human aspirations. Nations, social strata, regional and local governments, as well as individuals, compete against each other. The strongest competition occurs in an economy where rivalry takes place between companies competing for specific goods. It seems that competition cannot be eliminated from life, although its nature is constantly changing. Noteworthy is the element of cooperation that accompanies the original meaning of this term. Etymologically, “competitiveness” comes from the Latin *concurro* (*compete*) — which means running together (with someone) (Słownik Wyrazów Obcych, 2002, p. 585). The cooperation accompanies contemporary competition as an important element of creating and strengthening the potential of entities, including, in particular, the innovative potential (Dolińska, 2012, pp. 23–24). Few businesses can now successfully carry out innovation activities in isolation from their environment (Porter, 1990).

Cooperation in the sphere of innovation is a broad and very diverse concept. Cooperation is commonly understood as the ability to take specific and targeted actions in the presence of two or more participants. In the innovation activities of enterprises, cooperation is included in the types of external relations, next to open sources of information and acquisition of knowledge and technologies, which together constitute significant support for risky and costly innovative processes (Krawczyk, 2013, pp. 15–16). It is distinguished by the activity of enterprises in joint scientific, technical, financial, organizational, and commercial activities, which may lead to the implementation of innovations. According to this approach, cooperation within the scope of innovation activities of companies means their active participation in joint projects with other companies or non-commercial institutions, especially in the field of research and development (R&D). This cooperation can be forward-looking and long-term for the partners. Furthermore, it may not necessarily bring direct and measurable economic

benefits for the participants. However, it is stressed that such cooperation must not involve subcontracting of works without active participation in their creation (Innovation Activity of Enterprises in the years 2015–2017, 2018). Companies producing the same type of products and having complementary assets can cooperate in developing new technologies, products, processes, and marketing concepts, using various forms of cooperation, including strategic alliances (Oslo Manual, 2005, pp. 84–85). The broad scope of cooperation means that it takes place not only horizontally, i.e. between companies and other institutions, but also along the supply chain, involving customers and suppliers in the development of new solutions. Partner institutions engaged in these forms of cooperation include primarily: enterprises belonging to the same group, suppliers, customers, competitors, consulting companies, commercial laboratories, private and public R&D institutions, research institutes, universities (Oslo Manual, 2005).

The cooperation of enterprises in the regional dimension is manifested in the creation and development of regional innovation systems, which constitute a network of cooperating actors of social and economic life. Cooperation of enterprises, especially with the R&D sphere, builds the innovative potential of regions and thus can be considered as the basis for the competitiveness of regions (Ferreira *et al.*, 2014). Furthermore, as demonstrated by the Community Innovation Survey in the European Union countries, there is more cooperation and interaction between the elements of the innovation system at the regional level than at the national level (Gierańczyk & Sadoch, 2015). The concept of regional innovation systems is in line with cluster theory in terms of approaches to stimulating growth. It involves industry, R&D, education, and public authorities that create complementary and interdependent systems. They are complemented by space-specific cultural features, communication methods, and trust levels. The competitiveness and innovativeness of the participants of the regional innovation system depend on the possibility of using the distributed knowledge for the needs of innovative solutions. In this way, a network is created within which participants benefit from the generation and diffusion of innovations.

One of the forms of cooperation of enterprises in the area of innovation is clusters, which Porter (2008) considers to be geographical concentrations of complementary and closely related suppliers, related sectors, and specialized institutions. Links within a cluster and its relations with the environment are a unique feature of each cluster.

A lot of the literature is devoted to the motives and effects of cooperation between enterprises in innovation activities. There are also increasingly more papers dedicated to the diversity of partners. Relatively little is

committed to discussing the spatial aspects of cooperation in innovation activities. The conducted research emphasizes, above all, that cooperation with a variety of many partners provides an opportunity to learn about cooperating as well as innovation. Building the capacity of innovation activities through cooperation brings many benefits for the entities involved. Those of the highest priority include: access to knowledge and new technologies, possibilities of R&D activity co-financing and, consequently, reduction of costs of this activity, participation in complex innovation processes, non-duplication of R&D activities, less risk related to creating innovations, achieving economies of scale (De Faria *et al.*, 2010; Fritsch, 2001; Oslo Manual, 2005; Wilkinson & Young, 2002). Numerous studies prove the effects of cooperation in the form of an overall increase in the efficiency of companies, including labor productivity, and above all, an increase in the number of product and process innovations introduced (Stejskal *et al.*, 2016; Beers & Zand, 2014; Negassi, 2004; Veugelers & Cassiman, 2005). The positive effects of cooperation in the innovation activities of companies are also visible in the absence of formal cooperation agreements. Companies seeking radical innovation that do not formally collaborate in R&D gain access to knowledge through relationships with their clients and ad hoc collaboration with universities (Belderbos *et al.*, 2004). However, the value and impact of cooperation are not always clear cut. In an increasingly open and dispersed innovation system, the effects of cooperation may vary depending on the type of companies involved in the cooperation or their location (Howells *et al.*, 2012; Robin, & Schubert, 2013). Large enterprises, cooperating in the work on radical innovations, cooperate with a positive effect more often (Tether, 2002; Oyelaran-Oyeyinka & Abiola Adebowale, 2012). The ultimate effect, as it seems, is to gain and maintain a competitive advantage through access to specific resources of partners (Das & Teng, 2000, p. 38).

The cooperation of enterprises in innovation activities, as proven by the literature, means the ability to create bonds and cooperate to achieve the adopted objectives related to innovation processes and the resulting benefits. It is at the same time a necessity to achieve and maintain a competitive advantage in today's reality.

It seems justified to explore the issues of the spatial dimension of cooperation between enterprises on innovation activities, i.e. the diversity in the level of cooperation, as it may have a significant impact on the needs of companies in the field of public support for innovation activities. In this context, the question arises: what is the level and quality of cooperation of Polish enterprises as part of innovation activities in the regional perspective.

## Research method

Cluster analysis (agglomerative Ward's clustering method) allowing to identify similar objects-voivodeships in terms of the analyzed phenomenon (Ward, 1963) was used to achieve the research objective. This hierarchical method is often used to group objects, i.e. to classify spatial objects, where intragroup variability is taken into account. The distance between groups is determined as the relative value of the differences between the sums of squares of the distances between points and the centers of the groups to which the points belong (Strahl, 2006, p. 236). The agglomeration algorithm, calculated as a geometric distance in a multidimensional space (Euclidean distance), was used to group the regions. Euclidean distances are affected by unit differences between dimensions, used to calculate the distance, therefore, standardization was applied to obtain data of a comparable scale. By using the agglomeration algorithm — the grouping of units into larger and larger clusters — we obtain the hierarchical tree. Bearing in mind that the research results are influenced by the selected features, with the research method in question being used, it is possible to read from the dendrogram information relevant to the characteristics of the clusters formed. In the case of simple spatial cluster structures, classic methods of analysis are used, including Ward's method, due to the ease of recognizing structures, which is already difficult in the case of more complex ones. The number of units in the study is not large, and the data does not contain numerous untypical values, which proves the effectiveness of Ward's method and the legitimacy to use it in this study (Migdał-Najman & Najman, 2013).

The selection of diagnostic variables for studying cooperation of enterprises meets the substantive, formal, and statistical criteria (Strahl, 2006). The data available at the regional level in Local Data Bank of Statistics Poland and data made available by Polish Agency for Enterprise Development, i.e. Raport z inwentaryzacji klastrów w Polsce 2015 (Report on the inventory of clusters in Poland 2015, were used. The year 2016 was adopted for the study<sup>1</sup>. The official statistics on cooperation between enterprises in innovation activities used in the study reflects the degree of activity of enterprises both in cooperation in the field of innovation activities and involvement in cluster initiatives, based on the standard international methodology described in Oslo Manual prepared by OECD and Eurostat. Taking into account the

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<sup>1</sup> Due to the availability of data, the values of variables X<sub>6</sub> and X<sub>7</sub> are for 2015, based on the Polish Agency for Enterprise Development cluster inventory report. Moreover, in the statistics of Statistics Poland, data for variables X<sub>4</sub> and X<sub>5</sub> are available for the total of three years, here 2015–2017.

current achievements of the literature on the subject and the scope of the analysis undertaken in the study, a list of seven features to be studied was defined:

X<sub>1</sub> – Industrial enterprises cooperating within a cluster initiative or other formalized cooperation in % of innovation active enterprises in 2016 by voivodeship;

X<sub>2</sub> – Industrial enterprises that cooperated in innovation activities in % of all enterprises in 2016 by voivodeship;

X<sub>3</sub> – Service enterprises that cooperated in the scope of innovation activities in % of all enterprises in 2016 by voivodeship;

X<sub>4</sub> – Industrial enterprises that cooperated in innovation activities in 2015–2017 period in % of innovation-active enterprises by voivodeship;

X<sub>5</sub> – Service enterprises that cooperated in innovation activities in 2015–2017 period in % of innovation-active enterprises by voivodeship;

X<sub>6</sub> – Number of clusters by voivodeship (as of October 2015);

X<sub>7</sub> – Average number of entities in a cluster by voivodeship (as of October 2015).

The values of the coefficient of variation calculated for the above variables were above 13%, so all of them met the assumption of the reference threshold at the level of V=10%.

In the study, the characteristics describing the level of cooperation of industrial and service enterprises in relation to the total number of enterprises (X<sub>2</sub> and X<sub>3</sub>), as well as in relation to innovation-active enterprises (X<sub>4</sub> and X<sub>5</sub>) were adopted<sup>2</sup>.

One of the forms of cooperation of enterprises in the area of innovation is cluster cooperation, understood here as formalized cooperative relations of companies (letter of intent, association agreement, agreement on the establishment of a consortium) (Innovation Activity of Enterprises in the Years 2015–2017, 2018). Variable X<sub>1</sub> describes the level of involvement of industrial enterprises in cluster initiatives in the group of innovation active enterprises. In contrast, X<sub>6</sub> and X<sub>7</sub> are characterized by regional saturation with clusters and the average number of entities involved in the cluster initiative. Such entities include, apart from enterprises, scientific entities and business environment institutions, including entrepreneurship centers, innovation centers, and non-bank financial institutions (Buczyńska *et al.*, 2016).

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<sup>2</sup> Innovation-active enterprises are those that introduced at least one product or process innovation during the period under consideration or implemented at least one innovation project during that period, which was interrupted or abandoned during the period under consideration (not successfully completed) or not completed (i.e. continued) until the end of that period, after: Innovation Activity of Enterprises in the Years 2015–2017, 2018.

## Results

Recent years have shown a decrease in Polish enterprises' cooperation with their environment within the scope of innovation activities (Figure 1). The weakening of activity concerns both service and industrial companies. The highest percentage of enterprises (with 10–250 and more employees) involved in cooperation in the scope of innovation activities was recorded in the Podkarpackie Voivodeship (9.6% and 12.9% respectively). The lowest indicators were achieved in 2016 by the Świętokrzyskie Voivodeship in relation to industrial enterprises (4.7%) and the Opolskie Voivodeship in relation to service enterprises (0.6%). The situation changes when the percentage of enterprises cooperating within the scope of innovation activity in the percentage of innovation-active enterprises is taken into account. On average, nationwide industrial enterprises are more involved in cooperation in innovation activities than service companies (27.6% and 20.4%, respectively). The highest percentage of companies cooperating in the industry was in the Mazowieckie Voivodeship (35.4%) and the lowest in the Łódzkie Voivodeship (23%). The greatest diversity between regions is visible in the activities of service companies. Most of them cooperated in the scope of innovation activities in the Świętokrzyskie Voivodeship (32%), the least in the Zachodniopomorskie Voivodeship (only 3.1%), which means a 10-fold difference.

The interest of industrial enterprises (with 10–249 employees) in cluster initiatives also strongly differentiates voivodeships. The Podkarpackie Voivodeship is a definite leader here. Over 24% of industrial companies in the group of innovation-active enterprises in this region cooperate within a cluster initiative or other formalized cooperation (Figure 2). In three voivodeships this percentage does not exceed 6% (Warmińsko-Mazurskie, Dolnośląskie, and Łódzkie). On average, 11% of industrial enterprises in Poland are involved in this type of cooperation.

In the light of Polish Agency for Enterprise Development data, 134 clusters were identified in Poland, and their spatial distribution (based on the coordinator's seat) is uneven (Figure 3) (Buczyńska *et al.*, 2016, p. 17). The largest number of clusters is definitely found in the Śląskie Voivodeship — 28, and more than half less in the Mazowieckie Voivodeship — 13. 31% of all clusters in Poland are concentrated in these regions. The lowest number of clusters (up to 3) is found in the Opolskie, Warmińsko-Mazurskie, and Łódzkie Voivodeships. A large number of clusters in two voivodeships of Eastern Poland, i.e. Podkarpackie and Lubelskie, should be noted, which seems to result from public support for the creation and development of cluster initiatives in these regions. Nearly 5,900 entities oper-



ate in clusters in total. Clusters have 44 members on average. Large differences between the voivodeships occur. There are 4 times fewer entities per cluster in the Opolskie Voivodeship than in the Pomorskie Voivodeship. Most entities operate in the clusters of the Śląskie, Mazowieckie, Dolnośląskie, Wielkopolskie, Podkarpackie, and Lubelskie Voivodeships. However, this does not always coincide with the number of clusters in the voivodeship. In Dolnośląskie, for example, 554 entities are involved in clusters, while in Lubelskie — 443, with 11 clusters in each voivodeship.

In the grouping procedure using Ward's method, clusters of voivodeships with relatively homogeneous characteristics were distinguished (Figure 4). Subjectively evaluating the dendrogram, a cut-off was made at the link level of 5, distinguishing four clusters. The most numerous cluster is formed by the 10-element group of voivodeships. The Małopolskie, Mazowieckie, and Śląskie Voivodeships form the second largest group of objects in terms of number. The Pomorskie and Warmińsko-Mazurskie Voivodeships constitute a separate group. Podkarpackie, on the other hand, created a single cluster.

At the distance of the 4th link, five clusters were formed. Concerning the above, two voivodeships were distinguished from the most numerous group. The largest, 8-element set was created by the Dolnośląskie, Wielkopolskie, Łódzkie, Świętokrzyskie, Kujawsko-Pomorskie, Opolskie, Lubuskie, and Podlaskie Voivodeships. Separate 2-element clusters are composed of the Lubelskie and Zachodniopomorskie Voivodeships, as well as Pomorskie and Warmińsko-Mazurskie, respectively. Małopolskie, Mazowieckie, and Śląskie, on the other hand, form a 3-element set. The independent cluster, similarly as in the previous approach, is formed by Podkarpackie.

The distinctiveness of the Podkarpackie Voivodeship cluster is probably caused by its strong position in comparison to other regions in terms of the level of cooperation in innovation activities. For this region, three analyzed indicators took maximum values ( $X_1$ ,  $X_2$ , and  $X_3$ ). Compared to other units, the Podkarpackie Voivodeship is distinguished by the highest percentage of both industrial and service enterprises cooperating in the scope of innovation activities in the group of all enterprises. Podkarpackie definitely distances other voivodeships in terms of the involvement of industrial enterprises in cooperation within cluster initiatives or other formalized forms in relation to innovation active enterprises.

Also noteworthy are the Małopolskie, Mazowieckie, and Śląskie Voivodeships, which form independent sets in both perspectives. These voivodeships are some of the most innovative units in the country. Taking into account the introduced innovations, they were in the top five of the ranking

in 2016. Such a situation can be observed e.g. for the indicator of industrial enterprises that introduced at least one product or process innovation to the market during the period considered (new or significantly improved product or process) (Local Data Bank, 2019). Małopolskie is ranked 2nd, while Mazowieckie, and Śląskie are ranked 4th and 5th, with the indicator values being comparable for the first five voivodeships (between 22.47% and 20.73%). It is worth noting that the Podkarpackie Voivodeship was among the analyzed five voivodeships (3rd place in the country).

Similar results can be observed in the analysis of the average share of innovative enterprises in the total number of enterprises (Figure 5). The Mazowieckie, Małopolskie, Śląskie, and Podkarpackie Voivodeships, which form separate clusters, belong to the group of six regions with the highest indicator.

However, it is more difficult to justify the distinctiveness of clusters of the Pomorskie and Warmińsko-Mazurskie Voivodeships as well as the Lubelskie and Zachodniopomorskie Voivodeships. The observation of the analyzed indicators ( $X_1$ – $X_7$ ) does not allow to formulate unambiguous conclusions. There is a certain convergence in a relatively small number of clusters in Pomorskie and Warmińsko-Mazurskie, while in Lubelskie, and Zachodniopomorskie the cooperation of industrial and service enterprises in the scope of innovation activities in relation to all enterprises is on a similar level. Moreover, Lubelskie and Zachodniopomorskie Voivodeships are characterized by a similar level of share of innovative enterprises in the total number of enterprises.

## **Discussion**

The analysis reveals a relatively low level of activity of enterprises in cooperation towards innovation, which is at the same time strongly spatially diversified. There is also a convergence of these assessments with the general level of innovativeness of voivodeships, which was demonstrated by the selected measures of the innovativeness of companies. It also seems to confirm the results of a synthetic approach to the level of innovativeness of voivodeships. The outstanding clustering of the Mazowieckie, Małopolskie, and Śląskie Voivodeships in the study conducted by Miłek (2017, pp. 487–507) places these regions among the top innovative voivodeships. In 2010, Mazowieckie, Śląskie, and Małopolskie took the first three positions in the country. In the second year of the study, i.e. 2015, Mazowieckie and Małopolskie were the first two, while Śląskie ranked fourth in Poland. A deeper conclusion can be drawn by analyzing the socio-economic potential of re-

gions where innovation is the key factor. In other studies by this author, Mazowieckie, Śląskie, and Małopolskie Voivodeships are equally high in terms of the level of social and economic development (Miłek, 2018, p. 505). In 2015, this was the first, third, and fifth place in the country, respectively.

The convergence of high innovation activities of companies and their involvement in cooperation in innovation activities in the studies by Węgrzyn (2016, pp. 41–52) conducted at the level of European countries is also noticeable. The low level of cooperation of Polish enterprises is the reason for the poor assessment of the innovativeness of the economy in the international arena. By analyzing the aspects of cooperation of enterprises with partner institutions, the author argues that enterprises from the service sector in countries classified as innovation leaders cooperate in the scope of innovation activities with partner institutions to a much greater extent than in countries being modest and moderate innovators. The experience of many companies allows us to conclude that the companies cooperating in the area of innovation invest more in innovative potential and as a result perform better than non-cooperating companies. Insufficient involvement of Polish enterprises in cooperation with partner institutions is also emphasized by Sachpazid-Wójcicka (2018), who points out that cooperation of companies most often means cooperation with only one entity and usually has a national dimension. Wiśniewska and Janasz (2018, p. 142) go one step further, claiming that the negative assessment of Poland's innovation policy stems from the weak cooperation of industrial enterprises and scientific and research centers with their leading counterparts abroad. The necessity to strengthen the companies' involvement in cooperation within the scope of innovation activities, not only by enterprises themselves, seems to be justified. The intensification of cooperation with enterprises is expected by the companies themselves, which is highlighted by the research conducted in the Podlaskie Voivodeship (Ciborowski, 2014, p. 71). It showed that partners of enterprises, especially higher education institutions, function in the analyzed area in an inflexible and long-term manner, which makes such cooperation in today's fast-changing conditions unacceptable for companies. Similar conclusions can be drawn from the study of cooperation in innovation activities with business environment institutions, where a positive impact on the innovativeness of companies can be observed, but it varies depending on the type of business environment institutions (Gorączkowska, 2018, pp. 748–751). Again, the level of cooperation is unsatisfactory. It should be noted, however, that the cooperation of enterprises with partner institutions in the scope of innovation activities does not necessarily have a clear and positive impact. The complexity of innovation

processes was revealed in Szopik-Depczyńska (2015, pp. 196–198) research, where it was observed while studying primary industrial enterprises in the Śląskie Voivodeship that cooperation does not always have a positive impact on innovation parameters.

## **Conclusions**

In this paper, an attempt was made to synthesize the level of cooperation among enterprises in the scope of innovation activities based on data available in public statistics (Statistics Poland and Polish Agency for Enterprise Development). The analysis leads to the following conclusions:

1. The level of cooperation of industrial and service enterprises with partner institutions in the field of innovation activity should be assessed as low. Less than 7% of industrial enterprises and 4% of service enterprises cooperated in the field of innovation activities.
2. There is quite a significant difference in the activity of enterprises in the scope of cooperation in innovation activities. It is visible in relation to the cooperation of enterprises in the scope of innovation activities measured both for all enterprises and for innovation-active companies. On average in the country, industrial companies are more involved in cooperation in innovation activities compared to service companies. The highest percentage of companies cooperating in the industry was in the Mazowieckie Voivodeship, while the lowest — in the Łódzkie Voivodeship. The greatest diversity between regions is visible in the activities of service companies. Most of them cooperated in the scope of innovation activities in the Świętokrzyskie Voivodeship, while the fewest in Zachodniopomorskie, which means a 10-fold difference.
3. Activity in the scope of cluster cooperation undertaken by companies strongly diversifies voivodeships. Podkarpackie is a definite leader in cluster cooperation of industrial enterprises from the group of innovation-active enterprises, distancing subsequent voivodeships. In general, the largest number of clusters operate in Śląskie Voivodeship, while the smallest in Opolskie, Warmińsko-Mazurskie, and Łódzkie Voivodeships. A significant number of clusters in two voivodeships of Eastern Poland, i.e. Podkarpackie and Lubelskie, should be noted, which seems to result from public support for the creation and development of cluster initiatives. Aviation, metal industry, photonics and optoelectronics in Podkarpackie Voivodeship, ICT, metal industry, medicine and the food industry in Lubelskie Voivodeship, are examples of areas of cluster activity supported by public funds under programs co-financed by the Eu-

ropean Union. Their use in regions may constitute an opportunity to tighten cooperation in innovation activities, and in the longer term to increase the number of marketed innovations or the overall increase in the efficiency of cooperating companies.

4. The low level of cooperation in innovation activities corresponds to the number of marketed innovations. Regions characterized by a low level of cooperation in innovation activities also show a low level of innovativeness measured by the number of introduced innovations, as well as general development potential.
5. Grouping voivodeships using Ward's method reveals the characteristic clusters of Mazowieckie, Małopolskie, and Śląskie Voivodeships. These voivodeships are some of the most innovative units in the country. In Mazowieckie region, the average share of innovative enterprises in the total number of enterprises was the highest in the country. The regions of Małopolska and Śląsk are also in the top six voivodeships. Podkarpackie Voivodeship forms a separate cluster. The distinctiveness of this region's cluster is probably caused by its strong position in comparison to other units in terms of the level of cooperation in innovation activities. This voivodeship achieves the highest values of three indicators (out of the seven studied) in the country, at the same time distancing itself from other regions. The similarity of individual regions in the context of cooperation between enterprises may be an important source of information for directing public support for innovation activities.

One should be aware that the presented results do not constitute a complete analysis due to the complexity of the issues discussed and the limited data characterizing the cooperation of enterprises with partner institutions in innovation activities. However, they can be a starting point for more in-depth research. Among such areas, it is necessary to point out the issue of public support for initiating and deepening cooperation between companies, including, in particular, spatial and sector-specific public support and its effects.

The cooperation of enterprises with partner institutions is a key aspect of innovation activity, and the spatial approach to the cooperation of companies is its important context. An unsatisfactory level of cooperation in individual regions of the country may result in the national economy low innovativeness and affect the implementation of development priorities in the field of building an innovation system. As a member of the European Union, Poland is obliged to co-implement activities increasing the innovativeness of the integration group and contribute to the achievement of the assumed development goals. The significant differentiation in the level of cooperation between enterprises in Polish regions may adversely affect the

results achieved by the European Union. Considering the strong competitive pressure in the world, spatial differences in the cooperation of enterprises as part of innovation activities should be minimized through public support in initiating and strengthening the cooperation of companies and partner institutions and taking into account the regional specificity.

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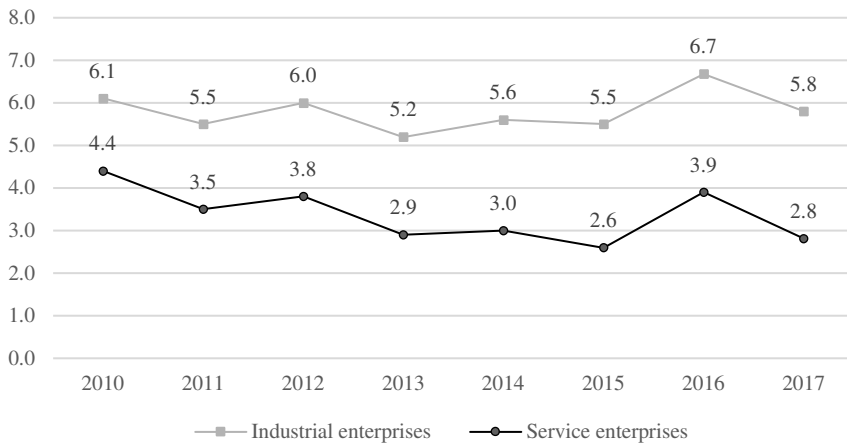
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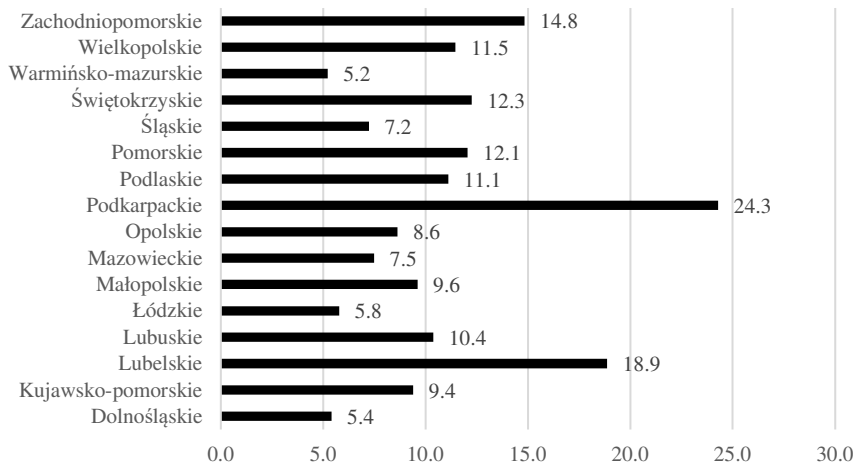
## Annex

**Figure 1.** Enterprises which cooperated in the scope of innovation activities in % of all enterprises in Poland in the years 2010–2017



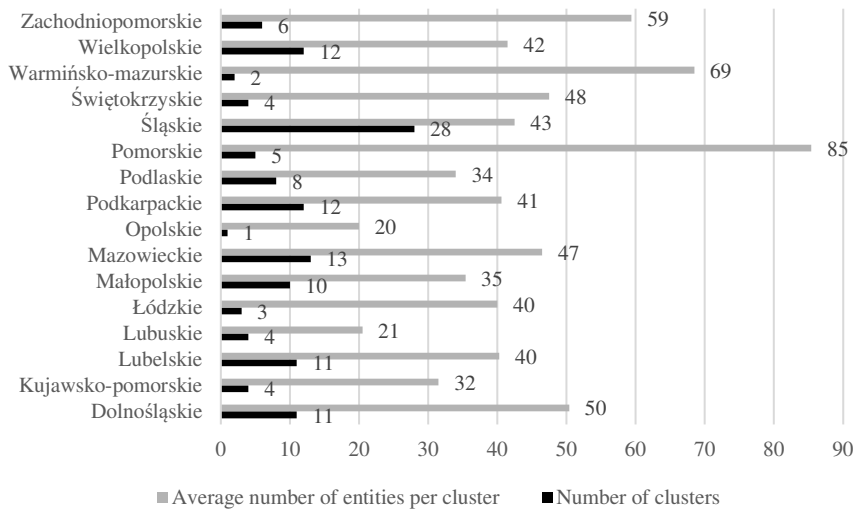
Source: own research based on LBD of Statistics Poland (2019).

**Figure 2.** Industrial enterprises cooperating within a cluster initiative or other formalized cooperation in % of innovation active enterprises in 2016



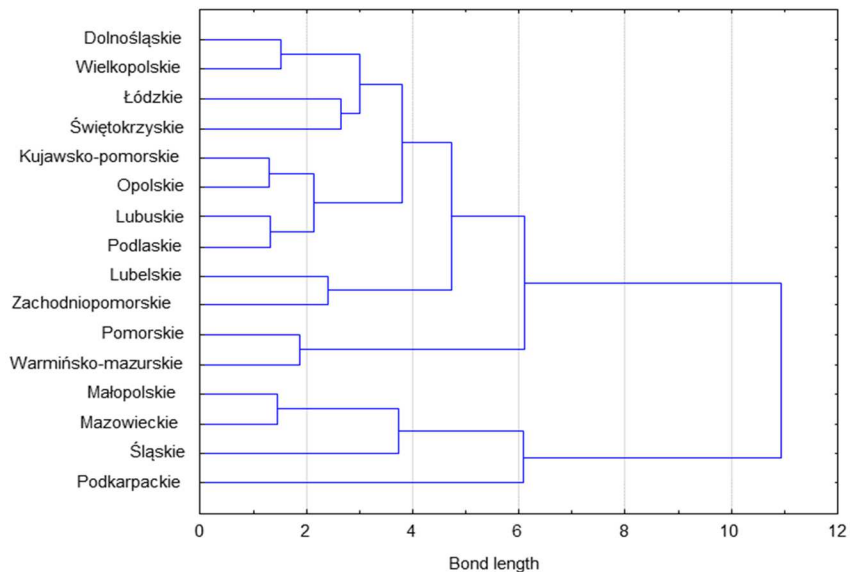
Source: own research based on LBD of Statistics Poland (2019).

**Figure 3.** The number of clusters and the average number of entities per cluster by voivodeships in 2015

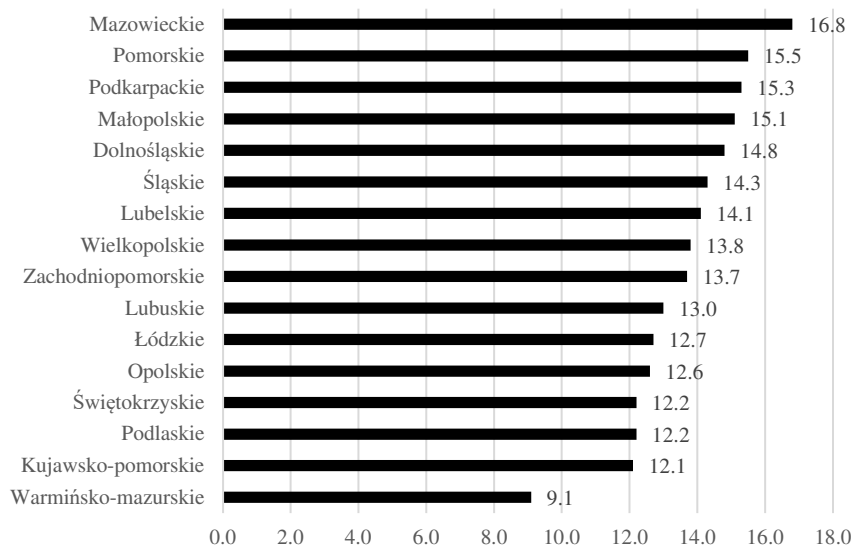


Source: own research based on: Buczyńska *et al.* (2016).

**Figure 4.** Classification of voivodeships in terms of the level of cooperation of enterprises using Ward's method



**Figure 5.** Average share of innovative enterprises in the total number of enterprises by voivodeships in 2016 (in %)



Source: own research based on LBD of Statistics Poland (2019).