TYPOLOGY OF POLISH NUTS 2 REGIONS REGARDING THE INTENSITY OF ENTERPRISE INNOVATION ACTIVITY

Elżbieta Sobczak – Dariusz Głuszczuk

Abstract

The article presents the classification of Polish NUTS 2 regions regarding the intensity of enterprise innovation activity. The research was carried out taking into account the scale of expenditure incurred by enterprises (input indicators) and the achieved results in the form of e.g., income earned for selling innovative products (output indicators). The classes comprising relatively homogenous Polish NUTS 2 regions were identified for the study. The analysis covering the composition and descriptive parameters was performed in relation to the obtained classes. Multidimensional statistical analysis was used for the research purposes, with particular emphasis on cluster analysis methods. The study covered 16 Polish NUTS 2 regions in the years 2008 and 2016. The statistical information, indispensable in identifying and quantifying enterprise innovation activity level in the cross-section of Polish NUTS 2 regions, was collected from the Local Data Bank (LDB), the largest Polish database about innovations. The objective of the study was to assess the diversity and transformations in Polish NUTS 2 regions' classification regarding input and output indicators of enterprise innovation activity level in the years 2008 and 2016.

Key words: enterprise innovation activity, cluster analysis methods, Polish NUTS 2 regions

JEL Code: O30, O18, C40

Introduction

Innovations are perceived either as a result or a process. Following the first approach and referring to the Oslo Manual (2005) terminology, an innovation stands for "*the implementation of a new or a significantly improved product (good or service) or process, a new marketing method or a new organizational method in business practice, workplace organization or relations with the environment*" (p. 46). These novelties or significant improvements are analysed from the perspective of an enterprise. It means that an innovation can represent an absolutely new solution in a global scale (creative innovation), or appear as a

result of imitation, or another application (imitative innovation). Regardless of the above observations, the common feature of creative and imitative innovations – approached as a result – is their implementation. However, the implementation of new or significantly improved products is documented by their market launching, whereas the processes or marketing and organizational methods by their actual usage in business operations (*Oslo Manual*, 2005, p. 46-47). A much broader significance is attributed to innovations perceived as processes. Following this approach, innovation is identified with the innovative activity[1] described by the sequence of events, initiated by the creation of an idea (inventiveness, invention), continued in the form of its embodiment (innovation), and finalised by its dissemination (imitation) (Schumpeter as cited Janasz & Kozioł, 2007, p. 33), or quoting modern definitions "*all the activities necessary for the creation and practical application of new solutions (...)*" (Stawasz & Niedbalska, 2011, p. 54). A similar approach is taken by the Oslo Manual, which defines innovation activities as *"all scientific, technological, organizational, financial and commercial steps which actually lead, or are intended to lead to the implementation of innovations"* and is embedded in a similar stream of trends." (*Oslo Manual*, 2005, p. 47). Some of these activities are themselves innovative, whereas others do not have the element of novelty, but are indispensable for innovations in terms of their result.

While analysing innovations from the perspective of their result and process, it is noticeable that the first of these concepts has an extremely pragmatic dimension since innovations are defined as new or significantly improved solutions, which have become the component of actual reality (e.g., new products or services launched on the market). The situation is different in understanding innovative activities. The criterion for its identification is not just the implementation of new or significantly improved solutions, but also the activities focused on this objective, not necessarily successful. The distinction between innovation as a result and a process has also a different, substantive dimension in the statistical terminology. The Oslo Manual adopts that an innovative company is an entity which implemented innovation in the period under consideration (*Oslo Manual*, 2005, p. 47). Therefore, its determining factor is an innovation as a result. An enterprise conducting innovative activities is not always capable of meeting this criterion. Continuing or abandoning activities aimed at implementing new or significantly improved solutions does not make such entity an innovative unit. In these cases we can talk about the innovative activity only. In other words, innovation-active companies are understood as enterprises conducting

[1] The innovative activity is also referred to as innovative processes (Szatkowski, 2001, p. 38).

innovation processes in the discussed period, including the ones continued, abandoned and finalised with an innovation implementation (*Oslo Manual*, 2005, p. 59).

It is clear from the above presented considerations that the innovative activity can and should be described in two ways, i.e. taking into account its scale and results. Based on this approach, the successfully completed innovation processes (innovation as a result) represent only a component of the innovative activity. It is complemented by the ongoing or abandoned activities aimed at the implementation of new solutions. However, the subject of observation is the innovative activity (innovation-oriented active companies) and the implemented innovations (innovative companies). The characteristics and relationships characterising these areas can be divided into input indicators (e.g., expenditure on the innovative activity) and output indicators (e.g., the results achieved by companies in selling innovative products). They are connected by the objective need to assess inputs and the achieved effects in the form of new or significantly improved solutions[2].

The innovation-oriented activity carried out in regions can be analysed through the prism of innovative activities performed by enterprises which location and range of impact are spatially diversified. The innovative activity represents one of the key factors facilitating enterprises in achieving their competitive advantage (Ahn, Yoon & Kim, 2018; Su, Lin & Wang, 2017). Intensive development of the innovative activity, carried out by enterprises has a direct impact on an increased regional competition (Cincalova, 2017). The subject literature presents the attempts to identify enterprises – innovation leaders, modest innovators, latecomers and non-innovators, characterised by the diversified intensity of innovative activities (Lesakova, Gundova, Kral & Ondrusova, 2017; Hu, Kang & Wu, 2017). The conducted research attempts to identify the relatively homogeneous classes of Polish NUTS 2 regions regarding intensity of the innovative activity carried out by enterprises located in their area. The profiles of these regions were also quantified as expenditure invested in the innovative activity and the effects of performed actions. It allowed identifying e.g., the regions representing both innovation leaders and non-innovators. The analysis of changes, which occurred in this area in the years 2008 and 2016, was also conducted.

1 Intensity of the innovative activity performed by enterprises – scope and methodological basis of research

[2] The analogical division of indicators is used in recognized innovation rankings, e.g., Regional Innovation Scoreboard (RIS) and Innovation Union Scoreboard (Plawgo, Klimczak, Czyż, Boguszewski & Kowalczyk 2013, p. 33).

The spatial range of conducted empirical research covers 16 Polish NUTS 2 regions. These Polish regions were classified in 2008 and in 2016 regarding the intensity of innovative activities carried out by enterprises located in their area. The discussed intensity is a complex phenomenon, described using the following indicators:

X_1 – share of expenditure on innovations in enterprises in domestic expenditure (%), X_2 – expenditure on innovations in enterprises per person employed (PLN), X_3 – enterprises which incurred expenditure on innovations (industry sector) (%), X_4 – enterprises which incurred expenditure on innovations (service sector) (%), 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 (%).

$X_1 – X_4$ indicators represent input indicators, because they reflect expenditure incurred in connection with the undertaken innovative activity, whereas $X_5 – X_7$ indicators determine the effects of these activities. The statistical information on input and output indicators originate from the Local Data Bank (LDB), the largest Polish database on innovations in the cross-section of regions. The classification of the analysed NUTS 2 regions, regarding intensity of the innovative activity, applying cluster analysis methods was carried out twice in 2008 and in 2016 using the following procedure (the review of information on distance measures and classification methods is presented in e.g., the studies by Anderberg (1973), Hartigan (1975):

- 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 (Kukuła, 2000):

$$z_{ij} = \frac{x_{ij} - \min\limits_{i} x_{ij}}{\max\limits_{i} x_{ij} - \min\limits_{i} x_{ij}} \quad (1)$$

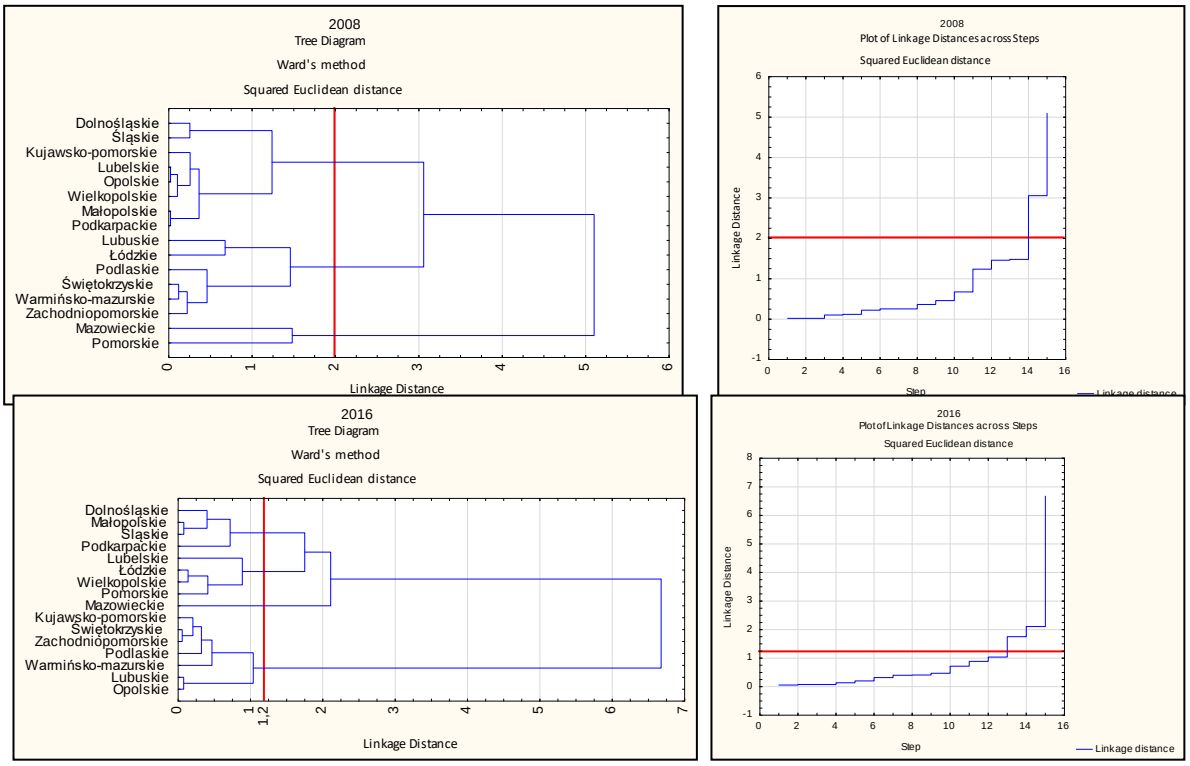
  z_{ij} – normalized value of j-th indicator in i-th region, x_{ij} – value of j- th indicator in i-th region.
- determining the diversification between the analysed regions regarding innovation intensity indicators using square Euclidean distance,
- hierarchical classification of regions using Ward's method,
- determining the number of classes, based on basic classification results, presented on a dendrogram and on a diagram of node distance against node stages,
- classifying regions using the k-means method and defining profiles of the obtained classes.

– comparing the classification results and analysing changes in 2016 against 2008.

2 Classification of Polish NUTS 2 regions regarding the intensity of enterprise innovation activity – empirical analysis results

Figure 1 illustrates the hierarchical classification results of the analysed regions' intensity regarding enterprise innovation activity in 2008 and 2016. Spanning trees and integration distance diagrams were used with regard to classification stages. Dendrogram, show the clusters and how each cluster is composed. The plot of linkage distances across steps indicates the cut-off point. On basis fig. 1, a variant division of 16 regions into three classes (in 2008) and four classes (in 2016), representing relatively homogenous enterprise innovation activity was suggested.

Fig. 1: Dendrogram of connections, integration distances and classification stages using Ward method for NUTS 2 level Polish regions in 2008 and 2016

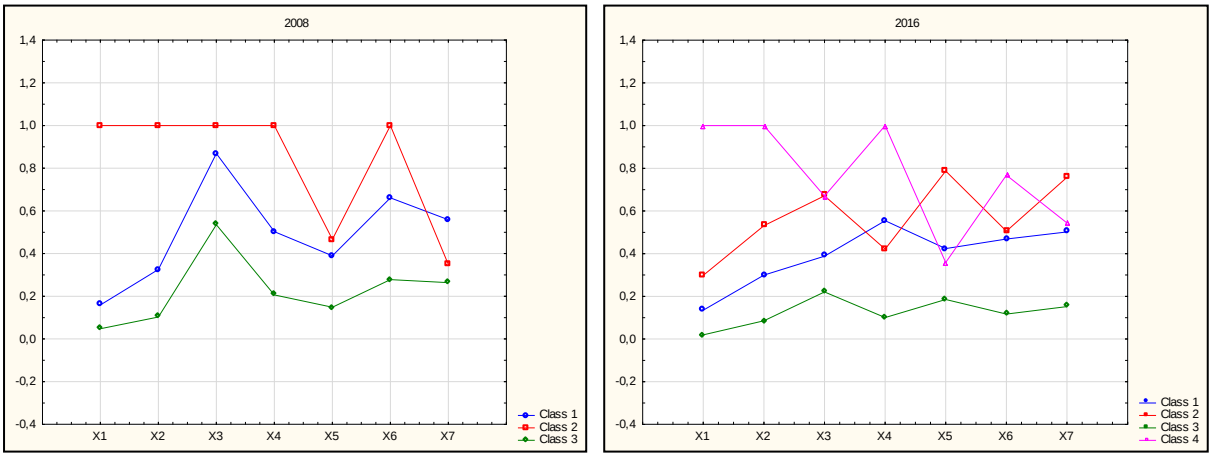


Source: authors' compilation based on the Local Data Bank applying STATISTICA 13,1 PL statistical package

The next step of research procedure covers the classification of Polish regions in 2008 and in 2016 using the *k*-means method. This method requires prior determination of the optimal number of classes. The optimal number of regional classes was accepted and determined using Ward method. Fig. 2 presents arithmetic means of normalized indicator values of innovation activity intensity achieved by enterprises X_1 – X_7 in 2008 and 2016 respectively.

The composition and class profiles covering regions, for the optimal division obtained as a result of using the *k*-means method in 2008 and in 2016 are presented in tab. 1 and 2 respectively.

Fig. 2: Mean values for normalized indicators of innovation activity intensity achieved by enterprises in 2008 and in 2016



Source: authors' compilation based on the Local Data Bank applying STATISTICA 13,1 PL statistical package

Tab. 1: Classification results of Polish regions using the *k*-means method regarding innovation activity of enterprises in 2008

Class No.	Specific nature of classes	Regions	Descriptive parameters	Indicators						
				X_1	X_2	X_3	X_4	X_5	X_6	X_7
1	Moderate innovator	Dolnośląskie, Kujawsko-pomorskie, Małopolskie, Śląskie Pomorskie, Podkarpackie	$\bar{x}$	6.6	1 979	18.5	12.8	16.8	19.9	38.0
			Me	5.8	2 013	18.7	13.0	14.0	19.9	35.3
			V	54.1	41.4	4.8	12.2	44.6	9.0	35.9
2	Innovation leader	Mazowieckie	$\bar{x}$, *Me*	36.8	4 932	19.8	17.9	18.7	23.9	27.3
			V	-	-	-	-	-	-	-
3	Modest innovator	Lubelskie, Lubuskie, Podlaskie, Opolskie, Wielkopolskie, Warmińsko-mazurskie, Łódzkie, Świętokrzyskie, Zachodniopomorskie	$\bar{x}$	2.6	1 003	15.2	9.8	10.8	15.3	23.0
			Me	1.3	858.4	15.9	10.2	9.2	16.0	26.8
			V	97.4	44.3	20.2	20.7	33.1	12.4	42.7

where: $\bar{x}$ – arithmetic mean, *Me* – median, *V* – variation coefficient (in %)
Source: authors' compilation based on Eurostat data using STATISTICA 13,1 PL statistical package

In 2008, 3 classes of Polish relatively homogeneous regions were identified regarding the intensity of the innovative activity carried out by enterprises. As Fig. 2 shows, the profiles of these classes are disjunctive due to X_1-X_6 innovation indicators, only the value of X_7 indicator, describing the percentage share of net sales income on products manufactured by high and

mid-high tech enterprises is lower in class 2 than in the regions included in class 1. Class 2, consisting of one element, referred to as the innovation leader, is formed by Mazowieckie region. It is a specific region, definitely different from the others, e.g., because it includes the capital city of Warsaw. In Mazowieckie region, the *input* innovation indicators, representing expenditure aimed at developing innovation in 2008, took maximum values against all other regions of Poland. Moreover, Mazowieckie region is also characterised by the highest average share of innovating enterprises (X_6) among all Polish regions.

Class 1 covers 6 regions featuring moderate level of innovation. The profile of this class of regions is characterised by a relatively low share of expenditure on innovation activity in enterprises against domestic expenditure (X_1), however, by a very high share of enterprises which incurred expenditure on the innovative activity in industry sector (X_3) and high share of innovating enterprises (X_6).

Tab. 2: Classification results of Polish regions using the *k*-means method regarding innovation activity of enterprises in 2016

Class No.	Specific nature of classes	Regions	Descriptive parameters	Indicators						
				X_1	X_2	X_3	X_4	X_5	X_6	X_7
1	Moderate innovator	Kujawsko-pomorskie, Lubelskie, Lubuskie, Łódzkie, Opolskie, Pomorskie, Wielkopolskie	$\bar{x}$	4.1	1459.7	14.1	10.3	8.9	15.6	30.8
			Me	2.5	1363.9	13.7	10.8	8.5	14.2	32.3
			V	80.3	47.7	10.2	33.6	25.6	24.0	24.8
2	Innovator	Dolnośląskie, Śląskie Małopolskie, Podkarpackie	$\bar{x}$	8.3	2289.5	16.7	8.6	13.7	16.1	43.8
			Me	9.5	2281.3	16.2	9.1	13.1	16.5	45.8
			V	31.8	18.7	13.3	19.3	14.0	12.6	27.2
3	Non-innovator	Podlaskie, Świętokrzyskie, Wamińsko-mazurskie, Zachodniopomorskie	$\bar{x}$	1.1	693.3	12.5	4.5	5.8	10.7	13.0
			Me	1.0	680.9	12.2	4.7	6.6	10.9	13.6
			V	52.0	41.4	16.5	21.3	27.7	11.6	55.7
4	Innovation leader	Mazowieckie	$\bar{x}$, *Me*	26.5	3 968.0	16.6	15.9	8.1	19.7	32.9
			V	-	-	-	-	-	-	-

where: $\bar{x}$ – arithmetic mean, *Me* – median, *V* – variation coefficient (in %)
Source: authors' compilation based on Eurostat data using STATISTICA 13,1 PL statistical package.

The largest class 3 includes 9 regions of modest innovators. The regions assigned to this class are characterised, regarding input indicators, by a very low share of expenditure on the innovative activity in enterprises against domestic expenditure (X_1), very low expenditure on the innovative activity in enterprises per person employed (X_2) and taking into account *output* indicators by a very low share of sold production of new or significantly improved products in industrial enterprises, in the total value of sold goods (X_5).

In 2016, 4 classes of regions characterised by different intensity of the innovative activity were identified. Mazowieckie region, forming a single element class 4, maintained its leading position. However, very high values of innovation activity indicators in relation to other regions occurred only regarding the share of expenditure on the innovative activity in enterprises against domestic expenditures (X_1), expenditure on the innovative activity in enterprises per person employed (X_2) and the share of enterprises which incurred expenditure on innovative activities in service sector (X_4) (cf. Fig. 2). While in 2008 a very high intensity of innovation activity, against other regions, referred to as many as 5 indicators (X_1-X_4 and X_6), this region's profile was characterised by lower values than in the case of class 2 and 1. It included regions classified, respectively, as moderate and modest innovators, the share of sold production of new or significantly improved products in industrial enterprises, in the total value of sold goods (X_5).

Class 2 of innovators covers 4 regions. The profile of this class was characterised by relatively high *output* indicators: the share of sold production of new or significantly improved products in industrial enterprises in the total value of sold goods (X_5) and the share of net sales income on products manufactured by high and mid-high tech enterprises (X_7), and *input* X_3 indicator defining the share of enterprises which incurred expenditure on the innovative activity in industry sector. The regions forming the class of innovators are characterised by a relatively low expenditure on innovations against domestic expenditure.

Class 1 covers the regions referred to as moderate innovators. This class of regions is characterised by average values, in relation to other values of all *output* indicators (X_5-X_7), by low expenditure on the innovative activity in enterprises per person employed (X_2) and low share of enterprises which incurred expenditure on the innovative activity in industry sector (X_3) and also a relatively low share of expenditure on the innovative activity in enterprises against domestic expenditures (X_1).

Non-innovators form the four-element class 3 of regions. The regions in this class are characterised by very low, against the others, values of all innovation activity indicators, regarding both *input* and *output* (cf. Fig. 2).

Conclusion

The following conclusions result from the conducted research on innovation activity of Polish regions in 2008 and 2016:

1. In 2008, three classes of Polish regions were identified, which can be described as the innovation leader, moderate and modest innovators. In 2016, the optimal classification of

regions regarding intensity of the innovative activity carried out by enterprises covered 4 classes, including the innovation leader, innovators, moderate innovators and non-innovators.

2. Mazowieckie region proved to be the innovation leader in both analysed years, however, this region's dominance over the remaining ones declined. Taking into account the values of all indicators included in the study, it is worth highlighting that in 2016 only one output indicator presented better values in this region. It was the share of net sales income on products manufactured by high and mid-high tech enterprises. The values of all other indicators went down.
3. In 2016, the class of non-innovators was identified and included 4 regions: Podlaskie, Świętokrzyskie, Warmińsko-Mazurskie and Zachodniopomorskie. In this class of regions the values of all indicators remained very low against the others. In 2008, all these regions were included in the class of modest innovators. It means that their ranking position against other Polish regions was lower in 2016.
4. Four regions included, in 2008, in the class of moderate innovators were moved to the class of innovators in 2016. It proves an improvement in their position against other regions as a result of their innovative activity. They include the following regions Dolnośląskie, Małopolskie, Podkarpackie and Śląskie.
5. In both analysed years, the regions in each of the separated classes were characterised by the definitely highest changeability regarding the share of expenditure incurred on the innovative activity in enterprises against domestic expenditure. The class of non-innovators is an exception, where the highest changeability was recorded in 2016 regarding the share of net sales income on products manufactured by high and mid-high tech enterprises.

Intensity of the innovative activity carried out by enterprises is of great importance as it represents the significant factor of regional development. The conducted research shows that there are clear disproportions in Poland in this respect. It should become the focus of interest from the perspective of the state's economic policy. The assessment of changes in the intensity of regional innovative activity should be monitored on an ongoing basis. It is worth continuing research in this area, covering e.g., the identification of factors stimulating and inhibiting the development of innovative activity undertaken by enterprises, as well as the assessment of its impact on regional development.

References

Ahn, S., Yoon, J. & Kim, Y. (2018). The innovation activities of small and medium-sized enterprises and their growth: quantile regression analysis and structural equation modelling. *Journal of Technology Transfer, 43*(2), 316-342.

Anderberg, M. R. (1973). *Cluster Analysis for Application*. New York, San Francisco, London: Academic Press.

Cincalova, S. (2017). Increasing the competitiveness and performance of enterprises focusing on innovation activity – empirical survey. In O. Dvoulety, M.Lukes & J. Misar (ed.), *Proceedings of the 5th International Conference Innovation Management, Entrepreneurship and Sustainability* (pp. 103-112). Prague: University of Economics, Prague.

Hartigan, J. A. (1975). *Clustering Algorithms*. New York: John Wiley & Sons.

Hu, M. C., Kang, J. S.& Wu, C. Y. (2017). Determinants of profiting from innovation activities: comparisons between technological leaders and latecomers. *Technological Forecasting and Social Change, 116*, 223-236.

Janasz, W. & Kozioł, K. (2007). *Determinanty działalności innowacyjnej przedsiębiorstw [Determinants of innovative activity of enterprises]*. Warsaw: Polish Economic Publishers.

Kukuła, K. (2000). *Metoda unitaryzacji zerowanej [Zero unitarization method]*. Warsaw: PWN Scientific Publishers.

Lesakova, L., Gundova, P., Kral, P. & Ondrusova, A. (2017). Innovation leaders, modest innovators and non-innovative SMEs in Slovakia: key factors and barriers of innovation activity. *Organizacija*, 50(4), 325-338.

Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data, (3rd ed.) (2005). OECD/European Communities.

Plawgo, B., Klimczak, T., Czyż, P., Boguszewski, R. & Kowalczyk, A. (2013). *Regionalne systemy innowacji w Polsce – raport z badań [Regional innovation systems in Poland – research report]*. Warsaw: Polish Agency for Enterprise Development.

Stawasz, E. & Niedbalska, G. (2011). Działalność innowacyjna *[Innovative activity]*. In K. Matusiak (ed.), *Innowacje i transfer technologii. Słownik pojęć [Innovation and technology transfer. The dictionary of terms]*. Warsaw: Polish Agency for Enterprise Development.

Su, Y., Lin, Z. Z. & Wang, C. G. (2017). The relationship between foreign competition and innovation activities based on quantile regression. *Science Technology and Society*, *22*(2), 165-181.

Szatkowski, K. (2001). Istota i rodzaje innowacji *[The essence and types of innovation]*. In M. Brzeziński (ed.), *Zarządzanie innowacjami [Management of technical and organizational innovations]*. Warsaw: Difin.

Contact

Prof. UE dr hab. Elżbieta Sobczak
Wrocław University of Economics
3 Nowowiejska Street
58-500 Jelenia Góra
elzbieta.sobczak@ue.wroc.pl

dr hab. Dariusz Głuszczuk
Wrocław University of Economics
3 Nowowiejska Street
58-500 Jelenia Góra
dariusz.gluszczuk@ue.wroc.pl