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COMPETITIVENESS OF INDUSTRY IN POLISH REGIONS

Summary: The aim of the paper is to first identify the factors which determine the competitiveness of the manufacturing sector as an element of region's competitive performance and then to determine their impact on economic performance, income and employment in the sector. The analyses were conducted for NUTS 3 for the period 2009–2011. Sixteen different diagnostic variables were adopted to describe entrepreneurship, innovativeness and competitiveness. Soft modelling was employed as a method to quantify regional competitiveness of the manufacturing sector as it allows an estimation of aggregate measures for latent variables and their interrelations.

Keywords: competitiveness, regional economy, soft modelling, manufacturing industry.

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1. Introduction

Spatial diversity is one of the main characteristics of contemporary economies. It may be explored at several levels: global, national or regional. The regional policy adopted by the European Union aims to support the activities promoting equal socio-economic conditions for all the community's regions. It pursues three main objectives: convergence (cohesion), better competitiveness of regions and higher employment, and European territorial collaboration. In Poland, the economy as a whole has been catching up with the EU average levels (external convergence), yet there are increasing internal disparities between regions (internal divergence). Based on the example of Polish regions, the author aims to identify the factors which determine the level of economy's competitiveness. Attention is paid in particular to entrepreneurship and innovativeness in the process. The analysis emphasises changes in the manufacturing sector.

2. The concept of regional competitiveness

Competitiveness is understood as potential for long-term and efficient development. It may be approached at different levels: global, regional and sectoral, or understood as the competitiveness of individual companies and products. According to the definition developed by the European Commission, competitiveness in the regional dimension is the ability of companies, industries, regions, nations and supra-national regions to generate, while being exposed to international competition, relatively high income and employment levels [*Sixth Periodic Report*... 1999].

The aim of the paper is to define factors underlying the competitiveness of the manufacturing sector as an element of regional competitiveness and their impact on economic performance as well as income and employment levels in the sector.

The key components of competitiveness include: economic advancement and diversification of the economy, level of technologies used by companies, development of high-tech industries, improvements concerning the quality and diversification of production, product and manufacturing process innovations.

Industry is a section of large-scale material production where mining for natural resources and their processing into products which satisfy consumers needs is based on the division of labour and the use of machinery.

Industry serves the following functions:

- production of investment goods, machinery and equipment employed by the national economy;
- source of innovation for the entire economy, as well as inventions, new technologies and methods of organization of labour, which contribute to reductions in production costs (innovations inspire also development of new products and create investment and consumption needs);
- source of budget income; it ensures employment, contributes to concentration of population in the cities, leads to changes in land development (it may deteriorate the quality of natural environment).

At present, advancements in science and technologies are playing an ever increasing role in industry. They include, for instance, biotechnologies (which make use of living creatures or their parts), nanotechnologies (based on the structures at the level of individual atoms and molecules), or information technologies (related to information management – computer science or telecommunication).

3. Methods of exploring competitiveness

One of the major problems related to the evaluation of competitiveness at the national or regional level is the multidimensional character of this variable. These phenomena are assessed based on the employment of a variety of partial indicators or an aggregate index. The most important and popular measures describing competitiveness include: the measure developed by the International Institute for Management Development, the World Economic Forum index, the Heritage Foundation economic freedom index, the UN social development index, and the R. Huggins Institute indicator [Bronisz 2013, pp. 45–57; Gardiner 2003]. In regional analyses taxonomic measures are used instead, e.g. Hellwig's development measure or the general distance measure developed by Walesiak [2011]. Yet another method involves an analysis of the main components.

For the purpose of the study, soft modelling was employed as an alternative method[1]. In a soft model, categories such as competitiveness are treated as latent variables. They are deferred indirectly from other variables which are directly observed and measured (indicators). A soft model consists of an outer model and an inner model. The preceding reflects the relations among latent variables. Outer models, in turn, represent the relations between latent variables and their corresponding indicators.

In outer models there are two types of relationships:

– latent variables (LV) reflect abstracts onto an indicator as it naturally appears – the measurement model in block j is $X_{ji} = \lambda_{j0} + \lambda_{ji}\xi_{ji} + \varepsilon_{ji}; i = 1,2,3, \dots, k;$
– latent variables (LV) is constructed or formulated from indicators – the measurement model in block j is $\xi_j = \pi_{j0} = +\sum \pi_{ji} X_{ji} + \delta_{ji})$ [2].

For the purpose of the modelling process, the partial method of least square has been employed. Its advantage, next to the ability to estimate latent variables, is also the ability to define interrelations among them. The first step in the process involves an iterative estimation of weights underlying the values of latent variables. In the second step, the parameters of the inner and outer model are estimated with the least squares method.

The resulting values of latent variables can be considered as the synthetic indicators of the complex phenomena under analysis. In the regions the soft modeling can be used to compare the level of such complex phenomena as competitiveness. On this basis, ordering regions can be made.

In the study it is assumed that the competitiveness of the manufacturing sector is determined by the number and the structure of enterprises in the sector. It is also assumed that the sector's economic performance is influenced by the introduction of innovation to production processes. These variables can be considered as latent

[1] Examples of similar studies employing the *Structural Equations Modelling* have been published, among others, in the following papers: Audretsch, Bönte, Keilbach [2009] and Wingwon, Piriyakul [2010, pp. 123–135].

[2] See: Wingwon, Piriyakul [2010, p. 127]. Soft modelling has been presented e.g. in: Gatnar [2003] and Korol [2008]. There are many statistical packages used in structural equation modeling and soft modeling, e.g. LISREL, SEPATH, AMOS, VPLS, Warp PLS. In the earlier publication, inter alia, one may mention: Klein [1998]; Byrne [2001]; Pollen [1989].

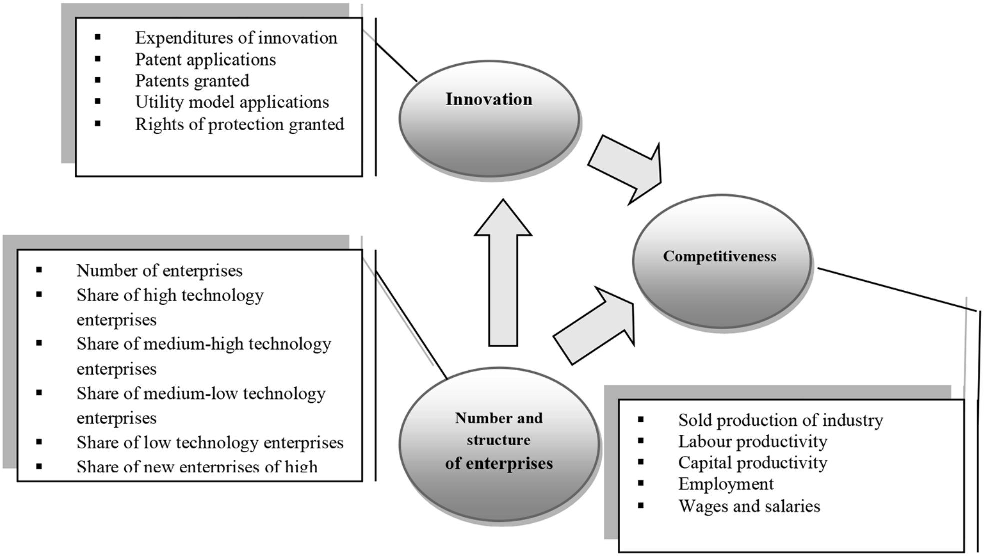


Figure 1. Research model for analysing relations in the manufacturing sector

Source: own study.

variables of the defined theoretical model. The relations between the variables and diagnostic measures are shown in Figure 1. A reflective approach has been adopted, where diagnostic measures such as production sold by the sector or labour and capital productivity are the reflection of their corresponding latent variables. This approach allows strong correlations between indicators so as to minimize the estimation error.

4. Statistical description of industry by regions

Industry, next to modern agriculture, is one of the basic sections of material production. The absolute figures describing industry's output and agriculture's total production as well as their shares in the total production determine, in turn, the development of other sectors of the economy such as construction, trade, transport, education, healthcare, etc.

According to the 2011 data, gross value added in industry (sections B, C, D, E) in Poland totalled PLN 343 244 million, which accounts for 25.6% of the total gross value added in the economy. Section C alone, i.e. manufacturing, had a 19.3% share. The sector employs an average of 2 251 221 people, which accounts for 23.0% of total employment in the national economy. The number of enterprises in the REGON register under section C amounts to 354 053, i.e. 9.1% of the total number of enterprises in the national economy. When analysing the level of technological advancements in enterprises, it should be pointed out that 2.0% of enterprises are high-tech, 6.5% belong to the medium-high technology group, 37.3% are in the medium-low technology group, and the remaining majority (54.2%) are low-tech companies. The breakdown of the NACE classification by technology level is presented in Table 1. Selected variables describing manufacturing by regions are shown in Table 2.

Table 1. Breakdown of the section Manufacturing by NACE divisions and OECD technology levels

High technology	
C.21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
C.26	Manufacture of computer, electronic and optical products
Medium-high technology	
C.20	Manufacture of chemicals and chemical products
C.27	Manufacture of electrical equipment
C.28	Manufacture of machinery and equipment not classified elsewhere
C.29	Manufacture of motor vehicles, trailers and semi-trailers
C.30	Manufacture of other transport equipment
Medium-low technology	
C.19	Manufacture of coke and refined petroleum products
C.22	Manufacture of rubber and plastic products
C.23	Manufacture of other non-metallic mineral products
C.24	Manufacture of basic metals
C.25	Manufacture of fabricated metal products, except machinery and equipment
C.33	Repair and installation of machinery and equipment
Low technology	
C.10	Manufacture of food products
C.11	Manufacture of beverages
C.12	Manufacture of tobacco products
C.13	Manufacture of textiles
C.14	Manufacture of wearing apparel
C.15	Manufacture of leather and related products
C.16	Manufacture of wood and of products of wood and cork
C.17	Manufacture of paper and paper products
C.18	Printing and reproduction of recorded media
C.31	Manufacture of furniture
C.32	Other manufacturing

Source: [*Nauka i technika*... 2013, p. 20].

Table 2. Statistical characteristics of diagnostic variables for the period between 2009 and 2011

	2009		2011		
Variable	$\bar{x}$	V_s	$\bar{x}$	V_s	Min/max
ξ_1 – Number and structure of enterprises					
X_1 – Number of enterprises in manufacturing per thousand population*	8.6	21.4	8.7	20.5	6.0 *Lubelskie* 12.1 *Pomorskie*
X_2 – Share of high technology enterprises	1.4	42.7	1.7	39.5	1.0 *Podkarpackie* 3.6 *Mazowieckie*
X_3 – Share of medium-high technology enterprises	5.9	21.8	6.2	20.5	4.4 *Małopolskie* 8.6 *Pomorskie*
X_4 – Share of medium-low technology enterprises	37.2	16.5	37.7	15.6	25.7 *Łódzkie* 50.0 *Pomorskie*
X_5 – Share of low technology enterprises	55.4	13.0	54.5	12.7	39.6 *Pomorskie* 67.7 *Łódzkie*
X_6 – Share of new enterprises of high and medium-high technology in total of new enterprises	6.9	22.2	7.0	22.1	4.9 *Warmińsko-mazurskie* 10.1 *Pomorskie*
ξ_2 – Innovation					
X_7 – Expenditures on innovation activities in industry *per capita* in PLN**	442.6	53.2	457.4	49.3	185.0 *Warmińsko--mazurskie* 907.0 *Łódzkie*
X_8 – Patent applications per 100 thousand population	6.6	42.2	8.9	32.7	4.4 *Warmińsko-mazurskie* 14.6 *Mazowieckie*
X_9 – Patents granted per 100 thousand population	3.4	48.8	4.5	49.6	0.9 *Podlaskie* 8.8 *Dolnośląskie*
X_{10} – Utility model applications per 100 thousand population	1.7	41.4	2.2	31.4	0.6 *Lubuskie* 3.6 *Śląskie*
X_{11} – Rights of protection granted per 100 thousand population	0.9	51.6	1.1	48.5	0.2 *Lubuskie* 2.2 *Małopolskie*
ξ_3 – Competitiveness					
X_{12} – Sold production of industry *per capita* in thousand PLN	20.6	36.2	25.7	36.9	13.2 *Lubelskie* 44.7 *Śląskie*
X_{13} – Gross value added in manufacturing per worker in thousand PLN	84.9	13.8	101.4	19.8	85.6 *Zachodniopomorskie* 166.0 *Dolnośląskie*
X_{14} – Gross value added in manufacturing per thousand PLN of gross value of fixed assets	525.1	9.06	535.9	12.4	427.0 *Opolskie* 744.0 *Dolnośląskie*
X_{15} – Average paid employment in manufacturing per thousand population	5.7	20.2	5.6	20.6	3.4 *Lubelskie* 8.5 *Wielkopolskie*
X_{16} – Average monthly gross wages and salaries in manufacturing in thousand PLN	2.66	9.97	2.97	9.67	2.60 *Łódzkie* 3.76 *Mazowieckie*

Legend: $\bar{x}$ – average, V_s coefficient of variation; * Number of enterprises in the REGON register; ** Data concern enterprises employing more than 49 persons. Where no data were available, averages were used.

Source: own study.

A closer look at the manufacturing sector reveals substantial disparities between regions. The coefficients of variation calculated for the diagnostic variables range from 9.7 to 49.6%. The number of patents granted, the number of rights of protection granted and expenditure on innovation activity are three variables which reveal the greatest disparities among regions.

The number of enterprises in the manufacturing sector ranges from 6.0 to 12.1 per 1000 population, the highest figure being reported for *Pomorskie* and the lowest – for *Lubelskie*. The level of technology in enterprises also varies substantially with

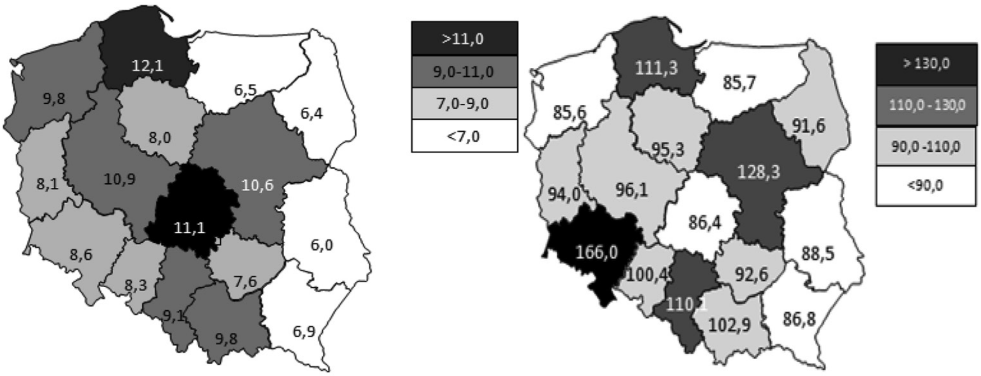


Figure 2. Number of enterprises per 1000 population in section C, and gross value added per employee (in thousand PLN) in 2011

Source: own study.

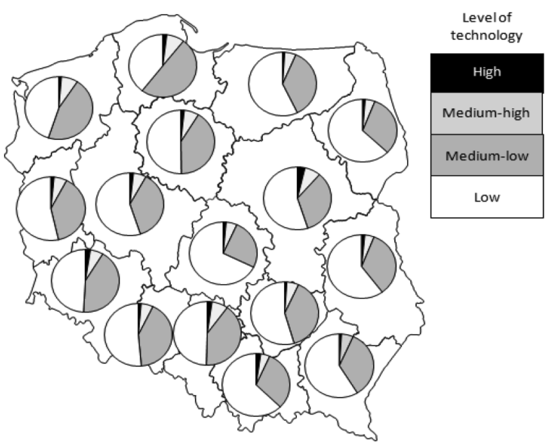


Figure 3. Section C enterprises by the level of technology in 2011

Source: own study

the region. The largest share of high-tech enterprises, 3.6%, is in *Mazowieckie*, and of medium-high technology enterprises – 8.6% – in *Pomorskie*. On the other hand, the highest share of low technology enterprises is reported in *Łódzkie* – 67.7%.

As far as labour productivity is concerned, the highest figure – PLN 166 000 per employee – is found in *Dolnośląskie*. Selected statistical data describing individual regions are shown in Figure 2 and 3.

5. Soft modelling in the evaluation of industry's competitiveness

The impact of the number and structure of enterprises and the level of innovation on the competitiveness of the manufacturing sector was verified with soft modelling, and for this purpose a standardization procedure was applied to statistical data. As a consequence, three outer models and one inner model were estimated with the partial method of least squares.

In the outer model, by means of an indicator, the latent variables were measured. The inner model defines the relationships between latent variables. The results are summarized below. The relations in the model are also shown in Figure 4 and 5.

The outer model of the latent variable – number and structure or enterprises:

$$
\begin{aligned}
X_1 &= 0.780 \cdot \xi_1, \\
X_2 &= 0.727 \cdot \xi_1, \\
X_3 &= 0.872 \cdot \xi_1, \\
X_4 &= 0.525 \cdot \xi_1, \overline{\text{var}} = 0.573, \\
X_5 &= -0.668 \cdot \xi_1, \\
X_6 &= 0.905 \cdot \xi_1.
\end{aligned}
$$

Weight relations:

$$\xi_1 = 0.255 \cdot X_1 + 0.374 \cdot X_2 + 0.229 \cdot X_3 + 0.054 \cdot X_4 - 0.121 \cdot X_5 + 0.245 \cdot X_6.$$

The outer model of the latent variable – innovation:

$$
\begin{aligned}
X_7 &= 0.813 \cdot \xi 2, \\
X_8 &= 0.917 \cdot \xi 2, \\
X_9 &= 0.901 \cdot \xi_2, \\
X_{10} &= 0.723 \cdot \xi_2, \overline{\text{var}} = 0.634, \\
X_{11} &= 0.579 \cdot \xi_2.
\end{aligned}
$$

Weight relations:

$$\xi_2 = 0.272 \cdot X_7 + 0.331 \cdot X_8 + 0.296 \cdot X_9 + 0.185 \cdot X_{10} + 0.128 \cdot X_{11}.$$

The outer model of the latent variable – competitiveness:

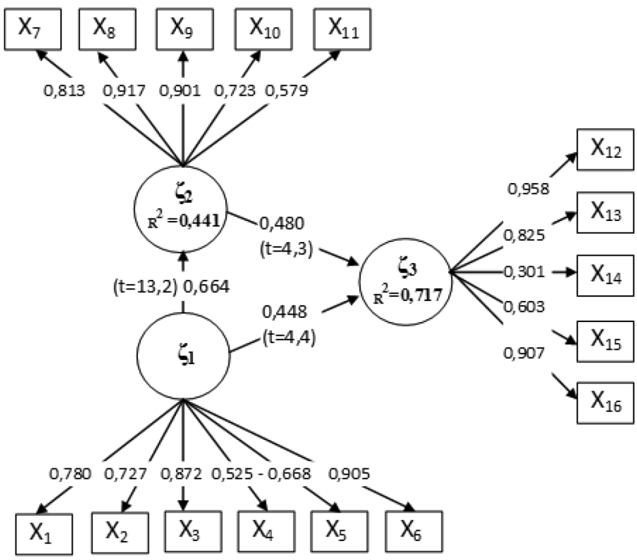
$$X_{12} = 0.958 \cdot \xi_3,$$
$$X_{13} = 0.825 \cdot \xi_3,$$
$$X_{14} = 0.301 \cdot \xi_3,$$
$$X_{15} = 0.603 \cdot \xi_3, \overline{\text{var}} = 0.575,$$
$$X_{16} = 0.907 \cdot \xi_3.$$

Weight relations:

$$\xi_3 = 0.362 \cdot X_{12} + 0.262 \cdot X_{13} + 0.033 \cdot X_{14} + 0.179 \cdot X_{15} + 0.352 \cdot X_{16}.$$

The inner model:

$$\xi_2 = \underset{(t=13,2)}{0.664} \cdot \xi_1, R^2 = 0.441,$$
$$\xi_3 = \underset{(t=4,4)}{0.448} \cdot \xi_1 + \underset{(t=4,3)}{0.480} \cdot \xi_2, R^2 = 0.717.$$



Weight relations:

$$\xi_1 = 0.255 \cdot X_1 + 0.374 \cdot X_2 + 0.229 \cdot X_3 + 0.054 \cdot X_4 - 0.121 \cdot X_5 + 0.245 \cdot X_6$$
$$\xi_2 = 0.272 \cdot X_7 + 0.331 \cdot X_8 + 0.296 \cdot X_9 + 0.185 \cdot X_{10} + 0.128 \cdot X_{11}$$
$$\xi_3 = 0.362 \cdot X_{12} + 0.262 \cdot X_{13} + 0.033 \cdot X_{14} + 0.179 \cdot X_{15} + 0.352 \cdot X_{16}$$

Figure 4. Estimated soft model of the relations in the manufacturing sector

Source: own study.

Based on the results, it may be concluded that all the correlations in outer models are statistically significant, and the signs in front of the parameters are justified. It may be assumed that the latent variable competitiveness of the manufacturing sector is reflected in: higher production sold in industry, labour productivity and productivity of fixed assets. It also translates into higher employment and income in the sector. The most accurate reflection of the latent variable competitiveness is the production sold in industry; the factor loading equals 0.958. To a lesser degree, this variable is also reflected in the productivity of fixed assets (0.301). Nonetheless, it is also a significant correlation.

Latent variable number and structure of the companies is explained: increase in the number of entities in the sector and qualitative changes. What testifies about them is an increase share in enterprise high, medium-high and medium-low technology and a decrease in the participation of entities in the field of low technology. The strongest of these is the correlations with the percentage of new businesses in the field of high and medium-high technology (0.905). The number of reported inventions is in the strong correlates with latent variable innovations (0.917). Positive correlations are also with the other indicators of the number of utility model applications, granted patents and proprietary rights, and the amount of expenditure for this activity. The parameters of inner models are interpreted as regression coefficients between the latent variables.

The relations in both inner models are also significant (as evidenced by the *t*-statistics), which indicates that the number and the structure of enterprises and their innovative activity are important determinants shaping the competitiveness of the manufacturing sector in regions. The model constructed in this study explains 44.1% (R^2) of the variation of the latent variable innovation and 71.7% of the variation of the latent variable competitiveness.[3] The variation of the sets of diagnostic variables in outer models ($\overline{\text{var}}$) is explained, on average, in 57.3, 57.5 and 63.4%, respectively.

The estimated values of the latent variable competitiveness of the manufacturing sector are shown in Table 3 and Figure 5. Spatial distribution is presented in Figure 6.

The values of latent variables are defined as the products of weights and standardized values of diagnostic variables. All the parameters of the weight relationships for the variable competitiveness are positive and its indicators are stimulants. This means that the larger the value of a variable, the higher the level of phenomena. With respect to the 2011 value of the latent variable competitiveness, four groups of regions can be distinguished. The highest competitiveness of the manufacturing sector is observed in *Mazowiecki*e. A similar level is found in *Dolnośląskie*. A medium-high level of the variable describes the following regions: *Śląskie*, *Wielkopolskie* and *Pomorskie*. The third group, comprising regions with

[3] The value of the Stone-Geiser statistic for the variable competitiveness equals 0.400, which indicates that the indicators for this variable predicted with the model are by 0.4 better that the results of the trivial prediction. When the value of the statistic equals 1, predictions are error free. A negative value indicates worse predictive qualities of the model in relation to the trivial prediction.

Table 3. Estimation of the latent variable competitiveness for the period 2009–2011

No.	Region	2009		2010		2011	
		Value	Rank	Value	Rank	Value	Rank
1.	*Dolnośląskie* (DL)	0.715	3	1.516	2	2.241	2
2.	*Kujawsko-pomorskie* (KP)	−0.519	8	−0.259	8	0.181	8
3.	*Lubelskie* (LL)	−1.619	16	−1.437	16	−0.992	16
4.	*Lubuskie* (LS)	−0.306	6	0.042	6	0.385	6
5.	*Łódzkie* (ŁD)	−0.848	11	−0.556	10	−0.120	10
6.	*Małopolskie* (MP)	−0.606	9	−0.299	9	0.313	7
7.	*Mazowieckie* (MZ)	1.292	1	1.740	1	2.500	1
8.	*Opolskie* (OP)	−0.318	7	−0.088	7	0.152	9
9.	*Podkarpackie* (PK)	−1.087	14	−0.798	12	−0.378	13
10.	*Podlaskie* (PS)	−1.298	15	−1.053	15	−0.638	15
11.	*Pomorskie* (PM)	0.198	5	0.417	5	1.073	5
12.	*Śląskie* (ŚL)	0.891	2	1.332	3	1.925	3
13.	*Świętokrzyskie* (ŚW)	−0.800	10	−0.691	11	−0.290	11
14.	*Warmińsko-mazurskie* (WM)	−1.059	13	−0.845	14	−0.437	14
15.	*Wielkopolskie* (WP)	0.495	4	0.727	4	1.304	4
16.	*Zachodniopomorskie* (ZP)	−0.981	12	−0.815	13	−0.303	12

Source: own study.

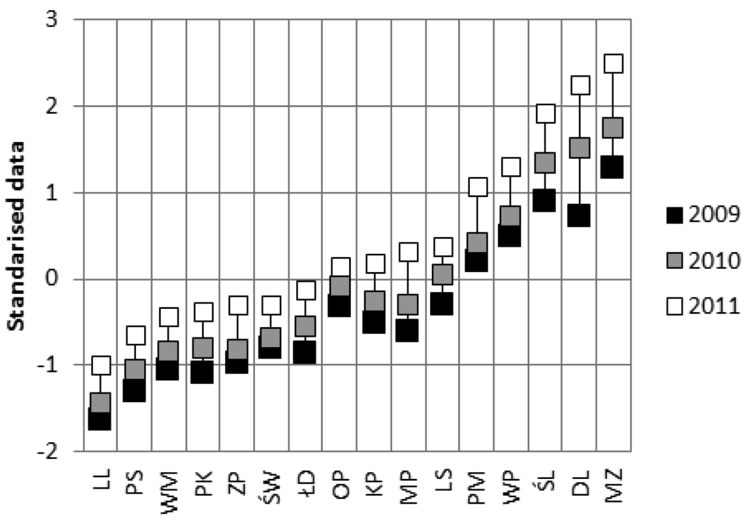


Figure 5. Latent variable competitiveness in the period 2009–2011

Source: own study.

medium-low competitiveness, includes: *Lubuskie*, *Kujawsko-pomorskie*, *Opolskie* and *Małopolskie*. The least competitive regions are those in the eastern part: *Warmińsko-mazurskie*, *Podlaskie*, *Lubelskie*, *Świętokrzyskie* and *Podkarpackie*. This group includes also two other regions: *Zachodniopomorskie* and *Łódzkie*.

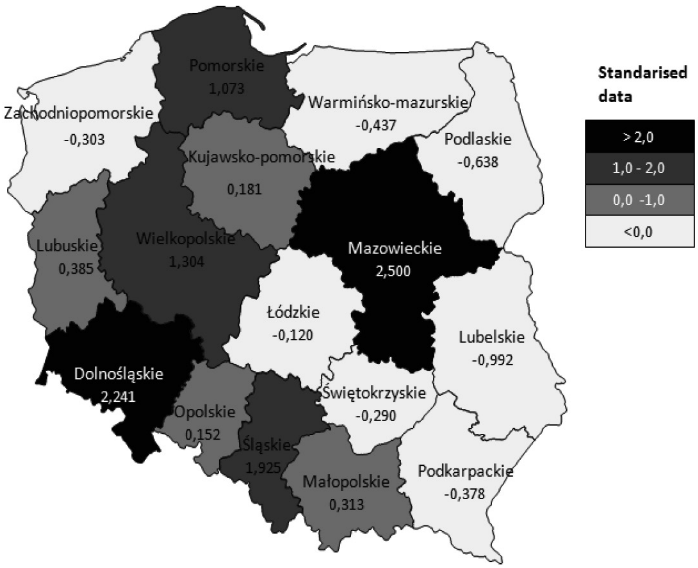


Figure 6. Spatial distribution of the latent variable competitiveness in 2011

Source: own study.

In the entire period of the analysis, the variable was rising in all the regions. The growth rates, however, varied with individual regions, which resulted in moving up and down the competitiveness ranking. In 2011, the following regions moved up in the ranking of the competitiveness of the manufacturing sector in relation to 2009: *Dolnośląskie*, *Łódzkie*, *Podkarpackie*, and particularly *Małopolskie* (two places). *Śląskie*, *Świętokrzyskie*, *Warmińsko-mazurskie* and *Opolskie*, on the other hand, moved down in the ranking (the latter – as many as two places).

6. Conclusions

The essence of the study is the use of soft modelling, as an alternative approach, in the analysis of the competitiveness of the industrial sector in the regions. This phenomenon belongs to the category of variables not directly measurable (latent variables). By means of the partial least squares method, the level of the competitiveness of the sector was estimated as a synthetic variable of the cross-section regions. The results obtained allow determining the spatial distribution of phenomena and developments in the sector. The constructed model served to specify relationships between variables characterizing the level of innovation, the number and structure of enterprises and competitiveness of the sector. There were substantive and statistical verification of the model. The applicability of the research method to the evaluation of the sector's competitiveness by regions was verified and proved by the reasonable correlations found in the models. The obtained values of latent variables provide grounds for arranging and grouping the regions, thus allowing an unambiguous identification of regions whose competitiveness in relation to the sector's average has either improved or deteriorated. One can clearly distinguish regions of growth or decline in the competitive position of the sector.

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KONKURENCYJNOŚĆ SEKTORA PRZEMYSŁU W REGIONALNEJ PRZESTRZENI POLSKI

Streszczenie: Celem badania przedstawionego w artykule jest określenie czynników konkurencyjności sektora przemysłowego jako elementu konkurencyjności regionów i ich wpływu na wyniki ekonomiczne oraz poziom wynagrodzeń i zatrudnienia w sektorze. Badanie przeprowadzono na poziomie NUTS 3 dla lat 2009–2011. Przyjęto 16 zmiennych diagnostycznych z obszarów przedsiębiorczości, innowacyjności i konkurencyjności. Jako metodę kwantyfikacji regionalnej konkurencyjności sektora przemysłu wybrano modelowanie miękkie. Zaletą tej metody jest możliwość oszacowania wartości syntetycznych zmiennych ukrytych oraz występujących pomiędzy nimi związków.

Słowa kluczowe: konkurencyjność, gospodarka regionalna, modelowanie miękkie, przetwórstwo przemysłowe.