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A Spatial Analysis Of The Knowledge - Based Economy In Poland

Abstract

The article presents a spatial analysis of the knowledge-based economy in Poland in regional terms in 2003 and 2011. Nowadays, knowledge is regarded as one of the factors of production besides land, labor and capital. The ability to create, collect and effectively use knowledge contributes to the generation of innovation, acquiring long-term competitive advantages and economic success.

Polish provinces are the basic territorial units, on which the calculations have been carried out. The period of time was purposely chosen to determine the impact of Polish accession to the European Union and the possibility of using the Structural Funds in the development of local economies based on knowledge.

The purpose of this article is to identify disparities in the use of knowledge in socio-economic life in the Polish provinces. The study was conducted using a taxonomic measure of development (one of the tools of multidimensional comparative analysis). Classification of provinces was constructed on the basis of KEI (Knowledge Economy Index) and KI (Knowledge Index) which are used by the World Bank in Knowledge Assessment Methodology (KAM). The division into four pillars (i.e. The Economic Incentive and Institutional Regime, The Innovation System, Education and Human Resources, Information and Communication Technology) attempts to explain the relationship between the factors of development.

***Keywords**: knowledge-based economy, measures of taxonomy, Knowledge Assessment Methodology*

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1. Introduction

Nowadays knowledge besides land, labor and capital is considered one of the factors of production. The ability to create and absorb knowledge and its effective usage contributes to generating innovation, attaining competitive advantages and achieving economic success. Knowledge should also be considered in a broader context, taking into account at least its four main components:

- systems of education, research and propagation of knowledge,
- society with traditions, customs, culture and patterns of behaviour,
- business entities with their market potential, development strategies, methods of using knowledge and skills of its absorption,
- state authorities with a commonly practiced policy (Świtalski 2005, pp. 139-140).

Along with the growing importance of knowledge for the economy new economic terms such as "network economy" or "digital economy" emerged. The most precise concept, which describes the upward trend of the importance of knowledge for the efficiency of socio-economic system is the "knowledge-based economy". This is the type of economy, which is based on the use of knowledge and information, both in the production and distribution (OECD 1996, p. 7). Entities (i.e. people, institutions, companies, etc.) acquire knowledge, distribute it and consequently are able to use it efficiently. They increase their own competitiveness basing the business on knowledge (Kukliński 2003, p. 195).

Knowledge has no limits and can be used anytime and anywhere, causing a total blurring of boundaries while leading a company (Drucker 1997, p. 22). It should also be noted that the importance of knowledge in contemporary economic systems is constantly increasing. This is manifested by:

- globalization of markets,
- a strong product and technological competitiveness which require flexibility and commitment in a changing business environment from the entrepreneur,
- a shortening life of products and a need a prompt creation of new goods,
- integration processes of product design, technology dissemination and a wider use of marketing, which contribute to achieving success in the market,
- changing an approach to the client (taking care of his needs and the efforts of his loyalty),
- numerous mergers and acquisitions, which is an indication of the ability to combine knowledge and experience,
- the rapid development of information and telecommunications technologies, and the universality of the Internet as the most effective way of communication (Kozarkiewicz-Chlebowska 2001, p. 3).

2. Theoretical aspects of knowledge based economy

The knowledge-based economy (KBE) term appeared in the 90's of the twentieth century. It was initially associated with the United States economy, where technological advances and manifestations of innovation can be noticed. This phenomenon has fairly quickly spread to the other highly developed, global economy (Wroniecki 2001, p. 9).

The definition of KBE dates back to 1960 when P. F. Drucker used the terms "working knowledge" and "knowledge society". The "knowledge economy", "information economy", "digital economy", "network economy", "knowledge driven economy" or "new economy" were treated as synonyms for the currently used term of knowledge-based economy (Jasinski 2009, pp. 16-20). In general KBE is associated with new technologies, innovation and technical progress, which is closely linked to the Internet revolution. However, a single, universally acceptable definition of the knowledge-based economy cannot be identiefied because this term is characterized by a wide variety of interpretations.

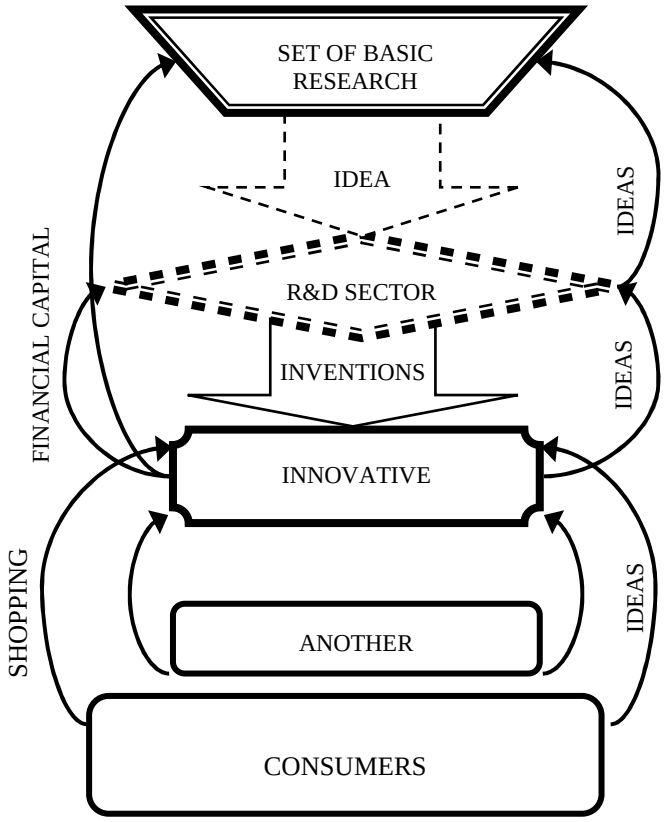
According to the Organisation for Economic Co-operation and Development (OECD) knowledge-based economy should be defined as an economy which directly based on the production, distribution and practical use of knowledge and information. Thus, according to this definition, there are three stages, which are the basis of economic development: production, distribution and implementation. However, knowledge becomes an added value, driving this development (OECD 1996, p. 7). Drucker believes that the KBE is an economic order, in which not work, capital, and raw materials, but knowledge becomes the most important resource. He also points out that the biggest challenge of KBE is removing the social inequalities (Drucker 1994, pp. 53-80).

The range of knowledge-based economy can be considered in two dimensions: the microeconomic and the macroeconomic one. The recognition of microeconomic dimension refers to business activities, which create a competitive advantage through the use of knowledge. However, a macroeconomic approach refers to the development of spheres related to the processing of information, the development of science, high technology industry and information society.

While seeking the relationship between innovation and entrepreneurship Schumpeter's theory, which was introduced into economic science in 1912, should be quoted. It was the first theor that described the genesis of innovation. It consisted of five combinations of different material components, which were combined with production capacity of a man. The meaning of these combinations is:

1. The introduction of completely new types of products to the market or specifically, one non-traditional product consumers are not familiar with, as they could not buy it before.
2. The introduction of new production techniques, i.e. methods so far untested in practice in the industry. These methods are designed not only to reduce production costs, but also they will positively influence the performance and efficiency of production, and their negative impact on the environment will be smaller than while using traditional techniques.
3. The creation of the modern market where the introduction of a new industry branch is planned.
4. The use of raw materials or semi-finished products that come from previously unknown sources.
5. The new coordination of industry, such as: the creation or fracture of monopoly position.

Figure 1. Scheme of Knowledge Based Economy



Source: own studies based (Dworak 2012, p. 33).

This perception of innovation covers many aspects that are taking place in the enterprises. It is connected with economic, technical, and organizational changes. Schumpeter pays a great attention to the fact that innovation is an economic event, but not a process involving the creation of knowledge. The result of this perception of innovation is a unique and one-time change (Schumpeter 1960, p. 60)

3. Measuring the level of the knowledge based economy

Measurement of economy knowledge is a very complex and complicated process. The Organization of the World Bank proposes Knowledge Assessment Methodology in this area, which is a part of the Knowledge for Development (K4D) program. KAM has been constantly improved since 1998. Today, this methodology consists of 148 variables (both quantitative and qualitative), which are collected for 146 countries. A regular and comprehensive analysis ensures the acquisition of more and more precise results. KAM methodology consists of four main pillars (Strożek 2013, pp. 108-109):

1. The Economic Incentive and Institutional Regime-responsible for the improvement of the economic policies and the activities of the institution. Dredging, spreading and use of knowledge in these units provide an effective action through the appropriate allocation of resources and to stimulate creativity.
2. The Innovation System – covering the activities of businesses, research centres, universities, advisory institutions and other organizations that adapt their activities to the preferences of increasingly demanding consumers.
3. Education and Human Resources – expressed through workforce that by increasing their skills, can adapt to the constantly evolving technology.
4. ICT – Information and Communication Technology – which provides effective communication and faster data transfer process. All these aspects affect the dissemination and processing of information and knowledge.

Referring to the pillars of KAM methodology, a data bank for the Polish provinces, consisting of 60 variables, was constructed. All statistics data was obtained from the Local Data Bank of the Central Statistical Office. KAM methodology is constructed for analysing national economies. Therefore, many variables had to be omitted because they did not differentiate the individual provinces significantly (e.g. trade policy or the possibility of opening own business).

Calculations were made by using the taxonomic measure of development. The process of creating the measure is as follows. Firstly the value of the coefficient of variation for all variables was calculated. This coefficient must be at a sufficiently high level. For further calculations variables for which $V_j > 10\%$ were used:

$$V_j = \frac{S_j}{\bar{x}_j} \cdot 100, \tag{1}$$

where: S_j is the standard deviation, $\bar{x}_j$ is the arithmetic mean from the sample.

The next step of analysis is to determine the nature of the variables. During grouping of all kinds of objects or areas three characters can be identified:

1. Nominants – any deviation in values of these variables is undesirable for the general characteristics of the studied phenomenon.
2. Stimulants – the higher value of these variables, the better for the general characteristics of the studied phenomenon. Therefore, what is desirable are positive parameters standing by these variables.
3. Destimulants – the lower value of these variables, the better for the general characteristics of the studied phenomenon. Therefore, what is desirable are negative parameters standing by these variables.

There is a possibility that the same variable in one study can accept the nature of stimulants and in the other one of destimulants. Everything depends on the phenomenon under study and the selection of variables. However, there should always be an unified nature of all diagnostic variables. Therefore, destimulants should be converted to stimulants and in order to do this their opposite values should be appointed (Suchecki 2010, p. 57).

The next stage of the study is an analysis of correlation coefficients values and removing variables that exhibit a strong correlation with other variables because they are carriers of the same information. As an acceptability threshold in this study the authors accepted the 0.7 value.

To standardize the variables quotient transformation was used. Thanks to that the data bank was brought to the mutual comparability:

$$z_{ij} = \frac{x_{ij}}{\bar{x}_j}, \ (i=1,\ldots,n;\ j=1,\ldots,m), \tag{2}$$

where:

- x_{ij} is the standardized variable, $\bar{x}_j$ is the mean of the population.

The next step in the study is to determine the pattern and anti-pattern of development according to the scheme:

- pattern of development $z_0 = [z_{01} \ z_{02} \ldots z_{0j} \ldots z_{0m}]$, where:

$$z_0 = \begin{cases} \max\limits_i z_{ij}, \text{ when the variable } z_{ij} \text{ is the stimulant,} \\ \min\limits_i z_{ij}, \text{ when the variable } z_{ij} \text{ is the destimulant,} \end{cases} \tag{3}$$

- anti-pattern of development $z_{-0} = [z_{-01} \ z_{-02} \ldots z_{-0j} \ldots z_{-0m}]$, where:

$$z_{-0} = \begin{cases} \min\limits_i z_{ij}, \text{ when the variable } z_{ij} \text{ is the stimulant,} \\ \max\limits_i z_{ij}, \text{ when the variable } z_{ij} \text{ is the destimulant.} \end{cases} \tag{4}$$

As in the examined phenomenon all variables were transformed into stimulants, the character of development pattern will take the highest values of test characteristics and the lowest for anti-patterns (Suchecki 2010, p. 63).

Then, the Euclidean Distance of each observation from a predetermined pattern of development should be calculated. This can be done by using the equation expressed in the form:

$$d_{i0} = \sqrt{\sum_{j=1}^{m} (z_{ij} - z_{0j})^2}, \ (i=1,2,\ldots,n), \tag{5}$$

where:

- z_{ij} is the standardized variable, z_{0j} is the pattern of development (Suchecki 2010, p. 63).

The last step of the analysis is a determination of taxonomic measure of development for all regions in Poland, which takes values from the interval (0, 10). The higher value of measure in a specific region, the greater development in this area:

$$m_i = (1 - \frac{d_{i0}}{d_0}) * 10, \ (i=1,2,\ldots,n), \tag{6}$$

where:

$$d_0 = \sqrt{\sum_{j=1}^{m} (z_{0j} - z_{-0j})^2}, \tag{7}$$

where:

- $z_{0j} - z_{-0j}$ is the distance between the pattern and anti-pattern of development (Suchecki 2010, p. 63).

4. KBE rating in the Polish provinces

Provinces were classified by using the taxonomic indicators of development, ranking from the best to the least developed ones in particular pillars, which were indicated by the World Bank for the years 2003 (see table 1) and 2011 (see table 2). Moreover, for both these years the Knowledge Economy Index (KEI) and the Knowledge Index (KI) were calculated. KEI for a specific region is the arithmetic mean of all taxonomic indicators, calculated for the individual pillars. KI is the arithmetic mean of taxonomic measures of development, calculated for the three pillars, i.e. The Innovation System, Education and Human Resources and ICT – Information and Communication Technology. KI estimated only a potential level of knowledge that exists in a specific region. Therefore, this index does not include the economic aspects of the functioning of the economy. In addition, the calculation of this measure always omitted the pillar of The Economic Incentive and Institutional Regime. If KEI is higher than KI in a given year, it means that the region takes full advantage of its knowledge potential (at a level, which is set by the KI measure). If KEI is lower than KI, it means that the region does not use all its knowledge potential. All results for the years 2003 and 2011 are presented in the tables below. A comparative analysis of all measures was made in the descriptions of tables. Time periods (i.e. 2003 and 2011) were selected, so as to see the effect of the Polish accession to the European Union and use of the Structural Funds in the development of local economies based on knowledge.

In 2003 when Poland joined the European Union, Mazowieckie province had the greatest potential of knowledge. No doubt, Warsaw had a considerable impact on this result as it is located in this region. The smallest potential of knowledge has been assigned for the Warmińsko-Mazurskie. It is also worth noting that in the midst of all the areas there is quite a large disparity (measure for the Mazowieckie is at the level of 7.77 and for Warmińsko-Mazurskie just at 1.25). The measure for the province, which occupies the second place in the ranking (Małopolskie) is at the level of 4.70, which is up by more than 3 units below the dominant – Mazowieckie (one major leader). Right behind Małopolskie there is Wielkopolskie province (4.25). The weakest one, next to Warminsko-Mazurskie was Lubelskie (1.50), Podkarpackie (1.81) and Podlaskie (1.94). KEI looks very similar to KI. The only minor differences of thess indexes can be extracted for Podkarpackie, Podlaskie, Kujawsko-Pomorskie and Pomorskie, which swapped their places in the rankings. Quite a significant decline of KEI relative to KI was recorded in Łódzkie.

Table 1. KAM values for 2003

PROVINCES	KEI	KI	Economic Regime	Innovation	Education	ICT
ŁÓDZKIE	2,87	3,14	2,06	1,49	4,73	3,20
MAZOWIECKIE	7,41	7,77	6,32	9,08	6,70	7,55
MAŁOPOLSKIE	4,47	4,70	3,78	4,90	4,01	5,21
ŚLĄSKIE	3,91	4,06	3,47	2,57	2,94	6,68
LUBELSKIE	1,70	1,50	2,30	0,85	2,83	0,80
PODKARPACKIE	2,14	1,81	3,16	1,23	2,61	1,58
PODLASKIE	2,11	1,94	2,63	0,60	2,74	2,48
ŚWIĘTOKRZYSKIE	2,17	2,17	2,18	1,99	1,94	2,58
LUBUSKIE	2,36	2,14	3,04	1,48	1,88	3,05
WIELKOPOLSKIE	4,30	4,25	4,45	3,63	4,25	4,87
ZACHODNIOPOMORSKIE	2,59	2,52	2,80	0,87	2,21	4,47
DOLNOŚLĄSKIE	3,47	3,41	3,66	1,79	2,98	5,45
OPOLSKIE	2,87	2,67	3,46	1,80	1,52	4,68
KUJAWSKO-POMORSKIE	3,25	3,05	3,84	2,05	3,02	4,08
POMORSKIE	3,15	3,43	2,31	2,05	2,48	5,75
WARMIŃSKO-MAZURSKIE	1,62	1,25	2,72	0,70	1,60	1,46

Source: own study.

Figure 2. Maps of the KEI and KI 2003

KEI

KI

Source: own studies.

To notice the spatial relationship between the studied areas visualization of the results were made and maps for individual measures were created (see figure 2). The darker colour, the higher value of the measures. The lighter colour, the lower value of the measures.

While analysing above maps it can be noticed that the smallest knowledge potential (expressed by Knowledge Index) was observed in eastern Poland, but the region looked much better in terms of Knowledge Economy Index. However, eastern provinces recorded the lowest values of the measures from all regions in Poland. A notable leader is Mazowieckie. Two southern provinces (Śląskie and Małopolskie) showed positive results. This group comprised also Wielkopolskie. Pomorskie, Kujawsko-Pomorskie and Dolnośląskie were located at the middle level. Łódzkie was in the lower group of KEI.

What seems surprising are relatively low measures observed for western provinces (Zachodnio-Pomorskie and Lubuskie). The location of these areas, directly on the border with Germany, should have a positive impact on the level of knowledge and measures of knowledge-based economy. However, in this case no such dependence was noted.

Table 2. KAM values for 2011

PROVINCES	KEI	KI	Economic Regime	Innovation	Education	ICT
ŁÓDZKIE	3,63	3,54	3,91	2,65	4,72	3,24
MAZOWIECKIE	6,42	6,31	6,76	7,66	6,31	4,95
MAŁOPOLSKIE	4,29	4,52	3,61	4,94	3,58	5,04
ŚLĄSKIE	4,47	4,67	3,86	3,40	3,14	7,47
LUBELSKIE	2,64	3,09	1,29	1,99	3,63	3,64
PODKARPACKIE	2,77	2,92	2,30	3,18	2,25	3,34
PODLASKIE	3,11	2,93	3,63	0,81	2,77	5,21
ŚWIĘTOKRZYSKIE	2,65	2,57	2,89	2,42	2,96	2,35
LUBUSKIE	1,86	1,87	1,83	0,99	1,90	2,73
WIELKOPOLSKIE	4,53	4,55	4,49	3,40	3,84	6,41
ZACHODNIOPOMORSKIE	2,59	2,43	3,07	2,41	2,77	2,10
DOLNOŚLĄSKIE	4,87	5,04	4,36	5,14	3,75	6,22
OPOLSKIE	2,74	2,68	2,91	2,20	2,24	3,60
KUJAWSKO-POMORSKIE	3,21	3,26	3,07	1,60	3,25	4,94
POMORSKIE	4,33	4,37	4,23	3,85	2,90	6,36
WARMIŃSKO-MAZURSKIE	2,01	1,91	2,30	1,26	2,07	2,40

Source: own study.

In year 2011 (similar to 2003), Mazowieckie province had the greatest knowledge potential. However, this region is characterized by a lower level of Knowledge Index than in the previous period. The smallest knowledge potential in 2011 was attributed to Lubuskie, which recorded an index fall compared to the previous period. Likewise, Warmińsko-Mazurskie, which was the last in the ranking for the year 2003 showed poor results. This region recorded a small increase of measure level compared to the previous period, however, Knowledge Index is still very low.

Developmental disparity between specific regions in Poland slightly decreased (first Mazowieckie – 6,31, previously Mazowieckie too – 7,77 and the last in the ranking Lubuskie – 1,87, previously Warmińsko-Mazurskie – 1,25). However, the pace of leveling of these inequalities is very slow.

Knowledge-based economy measure for Lubelskie reported a significantly lower level than the knowledge potential KI measure which is assigned to this region. This shows that this area does not fully exploit their potential. KEI index in the other provinces is similar to the KI index, which means that these areas use the possessed potential. However, the level of this potential could be better because general measures for the entire Poland are rather low.

In order to observe the spatial relationship (see figure 3) maps of KEI and KI, for the year 2011, as for 2003 were constructed. Similarly to figure 2, the darker colour means the higher value of the measures and the lighter colour, the lower value of the measures.

Figure 3. Maps of the KEI and KI 2011

KEI

KI

Source: own study.

Observing the map for the year 2011 the first and the most important thing is the reduction of inequalities between all areas. It may be noted that the regions, which are located on the eastern border of Poland, are marked with a little darker colour than it was in 2003. Warmińsko-Mazurskie has not improved their position. Lubuskie showed worse results than in the previous period.

Still, the one and only, not threatened leader is Mazowieckie. Just as in 2003 two southern provinces (Śląskie and Małopolskie) and Wielkopolskie performed well. Pomorskie and Dolnośląskie also joined this group. Łódzkie was characterized by a larger measure than in 2003. But it is still found in the second part of the rate ranking, though one of the largest cities in Poland is located in this area.

5. Conclusion

Measures of numerical taxonomy are very clear and do not bring the problems of interpretation. Furthermore, they allow for a graphical presentation of the results. Thanks to them, the objects can be classified and they are the best ways to verify the effectiveness of policies and effective use of available financial resources in these areas. Therefore, this article is a summary of provinces, on the basis of which knowledge-based economies on regional basis can be assessed.

Over the eight years, since Poland joined the European Union a reduction of developmental disparities in connection with the use of knowledge in social and economic life in the Polish provinces has been observed. However, it is still a long way to compensate the regional economic levels, if not impossible. The European Union Funds have a definitely high impact on the improvement of the existing situation. The most important program, influencing knowledge-based economy, was the Innovative Economy Operational Programme (IE OP) for 2007-2013. It should be noted that this article presented the test conducted to year 2011. Therefore, on the basis of these results, the effectiveness of the entire program cannot be determined but only a part of it (furthermore, the impact of the funds can often be noticeable several years after the completion of such a venture). IE OP can be called comprehensive because it had to improve not only the innovation of enterprises, but also an increase of competitiveness of science and technological progress. This improvement is manifested through computerization and use of new information and communication technologies. Moreover, IE OP leads to the fusion of science and business areas (inter alia, by R & D sector – Research and Development). It is worth mentioning that the Innovative Economy Operational Programme is a continuation of the Sectoral Operational Programme Improvement of the Competitiveness of Enterprises for years 2004-2006.

Eastern provinces, which before Poland's joining the EU were characterized by the lowest growth of all regions, were additionally covered by Operational Programme – Development of Eastern Poland (OP DEP). Thanks to this programme, eastern areas slightly reduced the gap to other, more developed, regions in Poland. OP DEP also included the aspects related to the knowledge economy. The financial support was intended to ensure driving the development of a competitive economy and the expansion of broadband lines in these areas.

There is no doubt that the innovations are often generated in urban areas. This is reflected in these regional studies. Provinces, within which large cities are located, were characterized by higher measures. It was visible for Mazowieckie (Warszawa), Dolnośląskie (Wrocław), Wielkopolskie (Poznań), Śląskie (Katowice), Małopolskie (Kraków) and Pomorskie (Trójmiasto). The exception from this rule was łódzkie, which did not receive such high results, despite the fact that within this province one of the biggest cities in Poland, Łódź is located.

Poland has still a long way to reduce a development disparities. However, it should be assumed that a good policy and rational use of European funds will contribute to the continuous reduction of these deviations, which will lead to faster socio-economic development in the whole country. These strategies cannot be constructed only on the basis of guesses and predictions. They must be supported by actual calculations.

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Streszczenie

PRZESTRZENNA ANALIZA GOSPODARKI OPARTEJ NA WIEDZY W POLSCE

Artykuł przedstawia przestrzenną analizę gospodarki opartej na wiedzy w Polsce w ujęciu regionalnym w latach 2003 i 2011. W dzisiejszych czasach wiedza jest uważana za jeden z czynników produkcji, obok ziemi, pracy i kapitału. Umiejętność wytwarzania i zdobywania wiedzy oraz jej efektywnego wykorzystania przyczynia się do generowania innowacji, zdobywania długotrwałych przewag konkurencyjnych i odnoszenia sukcesów gospodarczych.

Podstawowymi jednostkami terytorialnymi, na których przeprowadzono obliczenia są polskie województwa. Okres czasowy został dobrany w ten sposób, aby zobaczyć jaki wpływ na rozwój lokalnych gospodarek opartych na wiedzy miało wstąpienie Polski do Unii Europejskiej i możliwości korzystania z Funduszy Strukturalnych.

Celem artykułu jest wskazanie dysproporcji wykorzystania wiedzy w życiu społeczno-gospodarczym w polskich województwach. Badanie zostało przeprowadzone przy użyciu taksonomicznego miernika rozwoju (jednego z narzędzi wielowymiarowej analizy porównawczej). Klasyfikacja województw została skonstruowana na podstawie indeksów KEI (Knowledge Economy Index) oraz KI (Knowledge Index), wykorzystywanych przez Bank Światowy w metodologii KAM (Knowledge Assessment Methodology). Uwzględnienie czterech

głównych filarów (tj. system bodźców ekonomicznych, system innowacyjny, edukacja i jakość zasobów ludzkich oraz nowoczesna infrastruktura informacyjna) umożliwiło wskazanie relacji pomiędzy poszczególnymi czynnikami rozwoju.

***Słowa kluczowe**: gospodarka oparta na wiedzy, taksonomiczny miernik rozwoju, metodologia KAM (Knowledge Assessment Methodology)*