THE ROLE OF KNOWLEDGE IN THE SHAPING OF A KNOWLEDGE-BASED ECONOMY AND ECONOMIC DEVELOPMENT OF POLAND: A REGIONAL APPROACH

ZBYSZKO CHOJNICKI, TERESA CZYŻ

Adam Mickiewicz University, Institute of Socio-Economic Geography and Spatial Management
Poznań, Poland

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ABSTRACT. The article is concerned with examining the effect a knowledge-based economy (KBE) has on regional development in a model approach. The structural-developmental KBE model shows its three aspects and relations holding among them: (1) a knowledge base as the fundamental factor of regional development, (2) the sectoral structure of the economies of regions, (3) their level of economic development, and (4) interactions and relations holding among them. The research procedure consists of two parts. The first provides an interpretation of the terms of the KBE model in the regional pattern. The other uses the framework of an analytical-empirical model to give a description of Poland's regional system and how it differs in terms of KBE.

KEY WORDS: KBE, regional approach, structural-developmental KBE model, Poland's regional system in terms of KBE

Zbyszko Chojnicki, Teresa Czyż, Institute of Socio-Economic Geography and Spatial Management, Adam Mickiewicz University, ul. Dzięgielowa 27, 61-680 Poznań, Poland, e-mail: tczyz@amu.edu.pl

Introduction

Regional development in the context of KBE usually features as an element of programmes and conceptions rather than as an object of study, especially of analytical-empirical inquiry. Poland is no exception here, although recently there have appeared some works on this subject (cf. Kukliński 2003: 195–289; Chojnicki and Czyż 2003).

The adoption of the KBE concept in the study of regional development brings the role of knowledge in moulding economic development to the fore in the research. Various approaches to this subject can be distinguished. In a model approach, the object of study is a system composed of knowledge, a region's economy, and interactions between them. The model should be interpreted interactively rather than sequentially, i.e., assuming that there are mutual relations among its components (cf. Chojnicki 2003: 313).

The present article seeks to make this approach more concrete by employing an analytical model to study the shaping of knowledge-based regional economies in Poland. The regional system is a set of regions-voivodeships. The analytical model is structural-developmental in nature

and presents the formation and effect of KBE on socio-economic changes taking place in Poland's regional system. The model gives the characteristics of its three aspects, or terms, and relations holding among them: (1) factors of KBE growth, (2) the sectoral structure of the economies of the regions in question, (3) their level of economic development, and (4) interactions and relations holding among them.

Interpretation of the structural-developmental model of KBE in a regional approach

The interpretation of the aspects, or terms, of the structural-developmental model of KBE in a regional approach looks as follows (Fig. 1).

1. It is assumed that knowledge is the basic factor of regional development. Although in KBE studies knowledge is treated as an endogenous development factor, it is not the only one and its impact is not unidirectional because both, a region's fund of knowledge and its increase are determined to an extent by the region's socio-economic development. Hence, there is feedback with factors of socio-economic development. According to Meusburger (2001: 1), "knowledge, technological capabilities and skills are never evenly distributed in space. (...) Many forms of knowledge and cultural traditions are rooted in people and places and cannot easily be transferred from one region to another. Spatial disparities of knowledge and cultural traditions show a remarkable historical persistence. They must not be considered as transitory or short-lived. The speed at which new knowledge and information diffuses over space depends on the type of knowledge, the institutions within which the new knowledge is produced, the interest of the producer (inventor) to share his or her knowledge, the previous knowledge necessary to understand the contents of new information, the availability of technology necessary for the production and application of knowledge, and the inclination to accept the knowledge".

Thus, regions have their own internal factors favouring the growth of knowledge and its acquisition via transfer; they include the properties of a region's culture and some aspects of its human capital. Anyway, a knowledge 'deficit' and difficulties with its transfer need not be a permanent

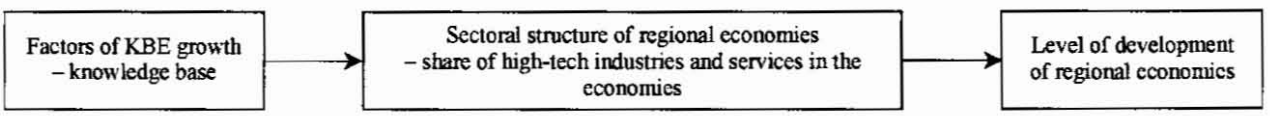

Fig. 1. The structural-developmental KBE model in a regional approach

determined, among other things, by the demand for a particular type of knowledge. Knowledge itself is an economic good, or at least some of its forms are, like private and tacit knowledge. We shall not go into such details as the kinds of knowledge and their associated tendencies towards its concentration and diffusion, or conditions of its transfer. These issues involve the internal structure of the regions' endowment with knowledge and the role of enterprises as carriers of knowledge and subjects of learning.

An important aspect of the role of knowledge as a regional growth factor is the unevenness of its distribution. The unevenness reflects the well-known rule of an uneven endowment of regions state of affairs and can be overcome, mainly through an active science-promoting policy.

The definition of knowledge as a factor of regional development poses serious difficulties from an analytical-empirical perspective. It cannot be considered exclusively in terms of its content, but also as a complex of properties representing its nature and functions that can be termed a knowledge base. The knowledge base of a region is a broad spectrum of theoretical properties reflecting various aspects of knowledge that potentially condition the region's socio-economic development in terms of KBE.

2. The sectoral structure of a region's economy is one of the principal aspects of its condition.

A description of the region's economy may cover its various internal and external aspects, especially its performance and effectiveness. A characterisation of the sectoral structure reveals the diversification of the economy and allows one to establish the importance and part of the individual sectors in economic activity.

In principle, the sectoral structure of the economy is static in nature, but when considered in KBE terms it allows its prospects for development to be determined, assuming that growth sectors are those that are sensitive to the impact of knowledge treated as a knowledge base. Thus, in KBE terms, it is crucial to identify those sectors of a region's economy that are considered part of KBE. According to Galar (2001: 139), they include primarily information and communications technology, but also those sectors that require highly skilled labour, like the car, chemical and machine-building industries as well as educational, financial and medical services. It should be emphasised, however, that in countries like Poland where the initial KBE level was low, the definition of criteria by which various industries as classified as high-tech must be more liberal and take into consideration the relations between the particular industries in the sectoral structure of regions. Thus, a study of the economic structure of a region should seek to determine which sectors of the economy are sensitive to the impact of knowledge, and what part of the economy is an element of KBE.

3. The level of economic development of regions is a state of their economies at a specified point in time which results from the processes of change. An analysis of those processes is not a matter of interest in the present article; the crucial thing is to establish the contribution of the KBE sector to the level of the economies. The definition of the level of development, which involves a number of indices, entails the adoption or the working out of a synthetic indicator that will allow a comparison of the development of the regions.

4. The relations and dependences hold among the three aspects, or terms, of KBE research in the regional approach on a vertical and a horizontal plane. Without going into details of the nature of those relations, we shall restrict ourselves to an analysis of the vertical ones, i.e. those holding between the aspects, or terms, of KBE formation, and disregard interactions among regions.

The network of interactions and relations under study is a highly complex one and has primarily been a subject of theoretical inquiry. Empirical research is hindered by difficulties with obtaining the relevant data in the regional approach.

The concretisation and statistical estimation of relations holding among interactions in the model adopted embraces two types of relations occurring in the set of regions under study: (1) the effect of KBE growth factors on the nature (properties) of KBE, and (2) the effect of KBE on the level of economic development of the regions.

Description of Poland's regional system in terms of KBE in a model approach

The model employed to describe Poland's regional system in terms of KBE is an analytical-empirical one composed of the following terms: (1) regional factors of KBE growth, (2) the sectoral structure of the regional economies from the perspective of KBE, (3) the level of the regions' economic development, and (4) relations among them.

1. The knowledge base as a factor of KBE growth with reference to Poland's regional structure includes the following aspects: human capital, social capital, knowledge-generating institutions, transfer of knowledge, outlays for knowledge generation, and the level of innovativeness (Table 1).

Important for the analysis are the choice and number of variables characterising the individual aspects of the knowledge base; they are determined by the availability of proper statistical information. The absence of data in regional statistics on some aspects of the knowledge base, usually social capital and the level of innovativeness in regions, deforms the input set of information and makes it impossible to determine the weight of the individual aspects of the knowledge base in shaping KBE. Researchers usually concentrate on human capital, the operation of higher schools and R&D institutions, and the level of

TABLE 1. ASPECTS OF THE KNOWLEDGE BASE IN A REGIONAL APPROACH

Human capital
1. Population with higher education aged 25-59 (in %)
2. Employment in research and development per 1,000 population
Social capital
3. Enterprises of natural persons per 1,000 population of the working age
4. Voter turnout in the referendum on Poland's accession to the EU (% of eligible voters)
5. Institutional efficiency of local governments (Swianiewicz's [2001] synthetic indicator)
6. Non-governmental social organisations (foundations, associations) per 10,000 population
Knowledge-generating institutions
7. State higher schools and non-state higher schools
8. Students per 1,000 population
9. Academic degrees conferred in higher schools
10. Share in national employment in R&D
11. Employment in R&D per 1,000 working population
Transfer of knowledge
12. Foreign scientific-technological solutions applied in the form of licence agreements in industrial plants
Outlays for knowledge generation
13. Outlays for R&D as % GDP
14. Outlays for innovation in industry per industrial worker (in thousand zlotys)
Level of innovativeness
15. Computers in industrial plants per 1,000 industrial workers
16. Proportion of households with personal computers

education, i.e. relatively readily available regional indicators. The aspect that is especially hard to include in a KBE growth model is social capital. This capital develops through social interactions at the regional level and expresses itself in various forms of social participation and social confidence. The problem at the operational level is one of social capital indicators. Among widely used ones are hard work, the tendency to practise economy, initiative, participation in voluntary associations, social solidarity, organisational efficiency, and trust in the local authorities, which are obtained from questionnaire data. It is worth emphasising that owing to a regional variability of social norms and social participation, social capital can be of great explanatory power as a factor of regional development. In turn, what makes the level of innovativeness as a factor determining KBE growth hard to accommodate are three reasons: (1) its nature has been difficult to quantify in Poland's transformation so far, (2) there are no official statistical data, and (3) it is necessary to separate the functioning of the regional innovation system (innovation generation, ways of implementing innovation, relations between firms and R&D units, foreign or domestic origins of innovation) from the efficiency of innovative activity undertaken in a KBE.

To identify the dimensions of the knowledge base, principal components analysis is employed. The transformation of the original variables describing the aspects of the knowledge base leads to distinguishing meta-variables called components. From among them first components are selected which account for the largest share of total variance and identify the main aspects and properties of the knowledge base treated as regional factors of KBE growth. The descriptive interpretation of the components as such factors consists in giving them a name that would generalise the meaning of the properties of the knowledge base contained in those components. However, factors of KBE growth in the form of principal components are highly complex, aggregate many aspects and properties of the knowledge base, and lead to substantial information loss.

Out of the set of 16 variables characterising the knowledge base in Poland's regional system in 2001, the first component distinguished (cv_1, accounting for 54.5% of total variance) is interpreted as a factor of 'the operation of higher schools and R&D institutions' embracing three aspects of the knowledge base (knowledge-generating institutions, transfer of knowledge, and outlays on knowledge generation), while the second component (cv_2, accounting for 15% of total variance) is correlated significantly with only one aspect of social capital and hence termed 'a factor of institutional efficiency of local governments'. The factors thus distinguished are disjoint and carry different weight (measured by the percentage of the total variance of the original properties of the knowledge base accounted for). The spatial distributions of the values of those factors are different.

2. The characterisation of the sectoral structure of the regional economies from the perspective of KBE embraces the description of the level of KBE and its share in the regions' industry and services.

KBE is a high-tech sector of the economy which is defined using the NACE classification (Table 2).

TABLE 2. HIGH-TECHNOLOGY SECTORS IN POLAND'S ECONOMY ACCORDING TO THE NOMENCLATURE OF ECONOMIC ACTIVITIES IN THE EUROPEAN UNION (NACE)

1. High-tech manufacturing industries:

D24 Manufacture of chemicals and chemical products
D29 Manufacture of machinery and equipment not elsewhere classified (n.e.c.)
D30 Manufacture of office machinery and computers
D31 Manufacture of electrical machinery and apparatus n.e.c.
D32 Manufacture of radio, television and communication equipment and apparatus
D33 Manufacture of medical, precision and optical instruments, watches and clocks
D34 Manufacture of motor vehicles, trailers and semi-trailers
D35 Manufacture of other transport equipment

2. High-tech services:

I64 Post and telecommunications
K72 Computer and related activities
K73 Research and development

3. Knowledge-intensive services:

I61 Water transport
I62 Air transport
I64 Post and telecommunications
J65 Financial intermediation, except insurance and pension funding
J66 Insurance and pension funding, except compulsory social security
K70 Real estate activities
K72 Computer and related activities
K73 Research and development
K74 Other business activities
M80 Education
N85 Health and social work
O92 Recreational, cultural and sporting activities

It should be emphasised that the size of the high-tech sector in Poland is merely an estimate because it is based on the aggregated statistics prepared by the Central Statistical Office by entire sections of the economy, which do not meet all the criteria of technological advancement set by the NACE classification (cf. Piekarec et al. 2000).

The importance of the high-tech sector in the economies of Poland and its regions is considered separately for manufacturing and services using the measures of the value of production sold and employment. The following KBE features in the regions are analysed:

- value of production of high-tech industries (g_1),
- employment in high-tech manufacturing sectors (g_2),
- employment in knowledge-intensive services (g_3),
- employment in high-tech services (g_4).

In 2001, high-tech industries contributed 22% to the value of Polish industry, with the share varying widely from region to region (between 36% and 8%). There were six regions (voivodeships) where this production concentrated (71% of its total value): Mazovia, Silesia, Lower Silesia, Wielkopolska, Pomerania, and Małopolska. Those where the value of production of high-tech industries was especially low included Warmia-Mazuria, Lubuska Land, Świętokrzyska Land, and Podlasie. That there is a strong relationship between the development of high-tech manufacturing and the regions' level of industrialisation (as measured by the value of production sold) is shown by the correlation coefficient amounting to 0.96. The analysis of this relationship is complemented by a comparison of the shares of voivodeships in the value of the country's total industrial output and the calculation of location quotients. The use of this indicator singles out Lower Silesia and Pomerania as voivodeships with a relatively strong position of high-tech manufacturing in the regions' industry, and Łódź as one of a low position of high-tech manufacturing relative to this region's industrial potential.

In 2001, high-tech manufacturing sectors accounted for 24% of Poland's industrial employment. As to regional differences in its distribution, they resembled those in the value of production.

Knowledge-intensive services (including high-tech ones) accounted for 42% of employment, while high-tech services, for 3.9% of service employment in Poland. In the regions, the proportion of know-ledge-intensive services in the service sector varied between 45% and 36%, and that of high-tech services, between 6% and 2.5%. Knowledge-intensive services, and simultaneously high-tech ones, concentrated in seven voivodeships: Mazovia, Silesia, Małopolska, Wielkopolska, Lower Silesia, Pomerania, and Łódź, i.e. those with large metropolitan areas. However, Mazovia was the only region whose location quotient showed it to have very well developed high-tech services, also in relation to the region's high service potential.

On the basis of employment in high-tech manufacturing and services, Poland's regions can be divided into four classes with a relatively very high, high, medium, or low KBE level (Fig. 2):

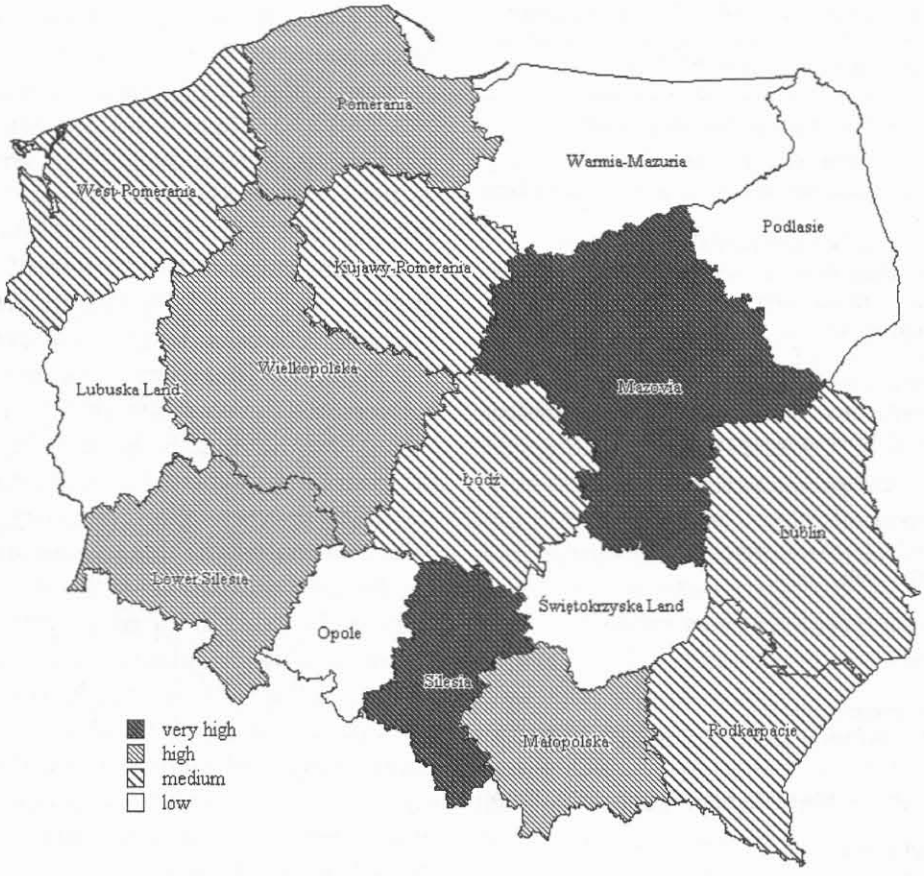

Fig. 2. KBE level on the basis of employment in high-tech manufacturing and services

(1) Mazovia and Silesia (100–200 thous.),

(2) Lower Silesia, Wielkopolska, Małopolska, and Pomerania (50–100 thous.),

(3) Łódź, Kujawy-Pomerania, Podkarpacie, West Pomerania, and Lublin (30–50 thous.), and

(4) Opole, Warmia-Mazuria, Lubuska Land, Świętokrzyska Land, and Podlasie (10–30 thous.).

3. A region's level of economic development is analysed as a set of various effects of economic activity, including KBE. It is made up of the region's economic potential expressed as per capita GDP and its increase, productivity and its dynamics, exports, and foreign investment over the years 1998–2001. The statistical (correlational) links among these characteristics of regional development are very strong. That is why this multivariate set can be reduced to significant dimensions using principal components analysis.

In 2001, the first component accounted for 55% of the variance of the original 7 variables in the country's regional system, and the second, for 22%. The first component (ev_1) is a meta-variable highly complex in terms of the original variables, and is interpreted as the component of a region's general potential. The second component (ev_2) is correlated significantly with only one original variable, and its interpretation poses no problems: it denotes 'the productivity dynamics of a regional economy'. These components, so different as to the phenomena they represent and importance, give the regional levels of economic development statistically significant dimensions, and their values have different spatial distributions.

4. Establishing the way in which KBE growth factors mould the nature of KBE allows the following questions to be formulated and answers to them to be justified:

(a) Which of the hypothetical factors is a positively verified KBE growth factor in the regional system?

(b) Do KBE growth factors show a close relationship with KBE properties emerging both in the manufacturing and the service sector of the regional economies?

(c) Does the adequacy of the model depend on the kind of measures of KBE activity used (high technology in terms of production value or employment)?

(d) Are there regional deviations from the dependence given in the model, in the form of residuals from regression, that may be evidence of still other factors controlling KBE formation in the regional system?

In turn, the analysis of the effect of KBE on the level of the regions' economic development seeks answers to the following questions:

(a) Do all the dimensions of the level of economic development show a statistically significant relation with KBE characteristics?

(b) Does the force of this relation vary with the particular KBE characteristic and its different measures?

(c) Does the formation of KBE characteristics in regions tend to aggravate regional discrepancies?

The relations whose existence is assumed in the analytical-empirical model and which display different characters and directions, are specified and estimated in two partial models.

(1) The first gives the effect of KBE growth factors (cv) on the properties of KBE (g) in Poland's regional system. The relation assumes the following general form of a multiple linear regression equation:

$$g_{ij} = b_0 + b_1 cv_{1j} + b_2 cv_{2j}$$

where:

g_{ij} = variable g_i in region j; $i = 1, 2, 3, 4$

cv_{mj} = factor cv_m in region j; $j = 1, 2, 3, ..., 16$; $m = 1, 2$

Employing stepwise regression leads to the elimination of the second explanatory variable (cv_2) and as a result, to a univariate model. The empirical concretisation of the model of how factor cv_1 affects the properties of KBE in the regional system leads to the following equations:

$g_1 = 5.18\ cv_1 + 7.02$ $\quad R^2 = 66.43\%$

$g_2 = 18.76\ cv_1 + 36.99$ $\quad R^2 = 57.22\%$

$g_3 = 114.31\ cv_1 + 175.23$ $\quad R^2 = 85.16\%$

$g_4 = 15.77\ cv_1 + 16.40$ $\quad R^2 = 88.83\%$

significant at $\alpha < 0.001$ level.

Relations between the factor of 'the operation of higher schools and R&D institutions' and KBE properties are statistically significant. The factor accounts for 57% to 88% of the variance of the KBE properties under study in the country's regional system. It has a stronger impact in the service sector than in manufacturing. In manufacturing, the strength of the connection between the factor in question and KBE varies with the measure of economic activity used: it is greater for the value of production than for employment figures. Residuals from regression calculated on the basis of the equations reveal regional deviations from this dependence. Significant negative residual values are displayed by regions that have a comparatively low KBE level with relation to 'the operation of higher schools and R&D institutions'. Significant positive residual values indicate a higher KBE level than might follow from its connection with 'the operation of higher schools and R&D institutions' factor. A relative KBE 'deficit' (negative residuals) in the manufacturing sector (variable g_1) and services (variable g_4) occurs in the voivodeship of Małopolska, and in the service sector only, in Pomerania. In turn, a relative KBE 'surplus' (positive residuals) both in the manufacturing and service sectors is characteristic of Silesia; in manufacturing, Lower Silesia and Wielkopolska, and in services, Mazovia. The appearance of regions that do not display a level of KBE development proportional to their endowment with higher schools and R&D institutions can be commented on in the following way: (1) the impact of the factor in question on KBE growth differs across the set of regions in nature and strength; and (2) the distribution of the regional residuals from regression provides a basis for the introduction of further explanatory variables into the model, which requires a continuation of the research.

(2) The other partial model gives the effect of KBE on the level of economic development of the regions. This relation is described by simple linear regression equations. Their number is determined by the number of dimensions of the level of economic development of the regions (dependent variables ev_1 and ev_2) and the number of KBE characteristics (independent variables g_1, g_2, g_3 and g_4) determining the level of

regional development. The modelling occurs separately for the high-tech manufacturing and service sectors, and yields equations of the following general form:

$$ev_{kj} = a_0 + a_1 g_{ij}$$

where:
ev_{kj} = dimension k of the development level of region j; $k = 1, 2$; $j = 1, 2, 3, ..., 16$;
g_{ij} = KBE (high technology) in the manufacturing sector (g_1, g_2) and in the service sector (g_3, g_4) of region j; $i = 1, 2, 3, 4$.

As a result of an estimation of regression coefficients, the following equations were obtained:

$ev_1 = 0.12\ g_1 - 0.87$ $R^2 = 62.84\%$

$ev_1 = 0.03\ g_2 - 1.05$ $R^2 = 49.26\%$

$ev_1 = 0.01\ g_3 - 1.08$ $R^2 = 58.19\%$

$ev_1 = 0.05\ g_4 - 0.79$ $R^2 = 64.30\%$

significant at $\alpha < 0.005$ level.

There is only one main dimension of regional development, viz. general economic potential (ev_1), that shows a statistically significant relation with KBE formation as represented by its four properties (g_1, g_2, g_3 and g_4). The level of KBE in the regional system has no significant effect on the other dimension of the regional economies, i.e., their productivity dynamics (ev_2). The KBE characteristics account for 49% to 64% of the total variance of the regions' general economic potential. The strongest connection holds between a regional KBE developed in the manufacturing sector as measured by the value of high-tech production and in the high-tech service sector as measured by employment, on the one hand, and the regions' general economic potential on the other. Residuals from regression of the regional economic potentials relative to KBE are small and show the regions' development to be proportional to KBE. There are some shifts in the positions of the regions on the scale of their economic potential 'reinforced' with KBE in comparison with their ranking by per capita GDP (Czyż 2001: 12). In the class of average regions, Małopolska moves to the top, while Podkarpacie and Lublin are promoted from the class of weak voivodeships to average ones.

The presented characterisation of the model describes the regional system and the disparities it reveals in the process of KBE development. It is not concerned with a reconstruction of the mechanism of KBE formation and impact. A fundamental role in the processes of KBE formation in the regional structure is played by links among enterprises, the scientific circles, and the institutional business environment, assisted actively by local authorities and supported by the state's regional policy. The principal KBE participants are firms located in a region, collaborating with scientific centres, knowledge transfer institutions, and units of local and business government, which are thought to be of fundamental importance in generating innovation. Thus, the modelling of KBE development in the region requires analyses and empirical research to be conducted in order to obtain detailed information at the level of enterprises concerning their innovative activity and its effects, as well as their role in KBE formation in the region. This is a task hard to implement, but of key importance in any attempt to reconstruct the process of KBE growth in the region.

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