7) advanced medical services, 8) the ecologically sustainable development of agriculture, 9) timber technology, 10) malleable metalworking, 11) domestic and international consultancy (especially as regards the economy and law).

An improvement in the situations of the aforementioned sectors of Poznań's economy would be founded on tacit and codified knowledge. It is, however, essential that efforts be made to fill the gaps between academe, industry and agriculture. There are loose feedbacks and networks of an opinion-giving and advisory character, that have born fruit in a strategic programme for the development of the economy of Poznań. Among the institutions active in the sphere of technology transfers, a particularly promising one is the Poznań Science and Technology Park. A further step should involve the capacity for innovation developed on the basis of advanced technologies brought in from abroad (in a model previously applied with success by Japan).

A separate issue needing to be worked on is the determination of satisfactory variants to any strategy for the development of a knowledge-based economy. Such variants may be taken through the conceptual phase through the generation of different combinations of tacit and codified knowledge, domestic and imported knowledge, cooperation between large corporations and the SMEs, the creation of new sectors and modernisation of existing ones, partnership between the public and private sectors and support for the development of small-scale innovation plus new technologies and products.

Conclusions

The simple correlations between the economy and knowledge do not offer a satisfactory description of the many and varied (very often complicated) interdependences linking these spheres. Of assistance in accounting for these interdependences would be some reconstruction of the processes ongoing at their fundaments. At present we still lack the operational methods that would allow for such a reconstruction. However, we may at least move in the right direction by identifying the agents and feedbacks operating in the transitional phase. A second method which does not at present allow for direct insights into the so-called „black box" of the economic-knowledge system would be what are known as neural nets. These are of value in that they allow for the inclusion in calculations of large numbers of input and output variables, for the construction of development scenarios and on this basis for indirect conclusion-drawing where transition processes are concerned.

ZBYSZKO CHOJNICKI
TERESA CZYŻ

POLAND ON THE ROAD TO A KNOWLEDGE-BASED ECONOMY: A REGIONAL APPROACH

Abstract: The aim of the paper is to present regional differences in the main aspects and dimensions of the knowledge base in Poland as the essential element of a knowledge-based economy, and to determine the relation between economic performance and the level of the knowledge base in a regional approach. The following are recognised as the structural aspects of the knowledge base in this approach: (1) human resources, (2) human capital, (3) social capital, (4) knowledge-generating institutions, (5) transfer of knowledge, (6) outlays for knowledge generation, and (7) the level of innovativeness. Significant attributes, or dimensions, of the knowledge base are identified using higher-order principal components analysis. The values of the meta-components are synthetic characteristics of the knowledge base; they provide a basis on which regional differences in the base are determined. The analysis of the dependence between a region's economic index (*per capita* income) and the dimensions of its knowledge base shows that in Poland during the transformation period the chances of the regions for knowledge-based development differ widely.

1. Introduction

1.1. Aim of the paper

The aim of the paper is to present regional differences in the main aspects and dimensions of the knowledge base in Poland as the essential element of a knowledge-based economy, and to determine the relation between economic performance and the level of the knowledge base in a regional approach.

1.2. Concept of a knowledge-based economy and the nature and role of knowledge

The concept of a knowledge-based economy rests on the assumption that knowledge is becoming the main factor of economic development and the formation of new economic structures. Other terms used in this context are 'knowledge-driven economy' and 'knowledge economy'. Problems concerning the knowledge-based economy have been the subject of many publications recently, especially those by the Organisation for Economic Co-operation and Development, which have popularised the concept and become a forum for its discussion (cf. OECD 1999, 2000a, 2000b; Chojnicki 2001).

Underlying the concept of the knowledge-based economy is the opinion that the traditional factors of economic growth, that is, land, natural resources, labour, and capital, while still important for economic activity, are being replaced by knowledge as the chief source of wealth and the most important factor of production. „Knowledge (...) is more than just the next critical factor of production. From economic perspective, it has two roles: it is a source of renewal and is also the glue that binds and co-ordinates other factors of production" (Schwartz, Kelly, Boyer 1999: 80).

In terms of the knowledge-based economy, the definition of the nature and role of knowledge has gained a new, wider meaning. A distinction can be drawn between public and private knowledge, which defines its character as an economic good and access to it. It implies another distinction, that between tacit and codified knowledge, which emphasises differences in its mediation and the type of public character. Knowledge can also be divided in functional terms into 'know-what' (information or knowledge about facts), 'know-why' (knowledge about scientific laws and theories), 'know-how' (skills or capacities to execute a task), and 'know-who' (knowledge about who knows what, and who knows what to do). In this approach, knowledge embraces not only scientific and technological progress, which acts through innovation, but also the process of learning, that is, „a process whose core is acquisition of competence and skills which lead to greater success in the pursuit of one's own goals or those of one's organisation" (Lundvall 2000: 126). Hence the term 'learning economy' besides 'knowledge-based economy'. In this context, a crucial role in the definition of the nature of knowledge, apart from its innovation function, is played by human aspects and social effects of knowledge which represent, respectively, the notions of human capital (knowledge, skills, competencies and attributes embodied in individuals) and social capital (networks together with shared norms, values, and understandings that facilitate co-operation within or among groups).

1.3. Knowledge base in a regional approach

In the research on socio-economic development in a regional approach, knowledge as a growth factor should be understood broadly as „capacity for action" (Stehr 1992: 2). In a structural aspect, it is the equipment of a region with those media and forms of knowledge and learning that can be defined as a knowledge base. Thus, the region's knowledge base is a set of media and forms of knowledge and learning which are potential conditions of the region's socio-economic development in terms of a knowledge-based economy.

The study of the knowledge base in a regional approach makes it necessary to establish its parts in a structural aspect. The study is hampered by the lack, on the one hand, of an operational concept of the knowledge base in the research on the knowledge-based economy and its indices, and on the other, by the lack of appropriate statistical information.

The available data needed to characterise the knowledge base with reference to the regional structure of Poland make it possible to distinguish in it the following parts which constitute the structural aspects of knowledge: (1) human resources, (2) human capital, (3) social capital, (4) knowledge-generating institutions, (5) transfer of knowledge, (6) outlays for knowledge generation, and (7) the level of innovativeness. Their choice, by no means exhaustive and complete, is determined primarily by the availability of regional statistics to characterise them.

1.4. Hypotheses and the research procedure

The following hypotheses are put forward in the paper:

1) the knowledge base determines the level of the regions' socio-economic development,
2) regional differences in the knowledge base strengthen the position of some regions on the scale of development, and
3) the relation between the knowledge base and investment outlays (needed for the development of education and innovation infrastructure) makes weak regions fall behind on the development path, which means a further reinforcement of regional differences.

The research procedure employed to verify these hypotheses includes:

1) the identification of the structural dimensions of the regional knowledge base,
2) an analysis of regional differences in the knowledge base, and
3) the determination of the strength of the relation between the regions' economic performance and the structural dimensions of the regional knowledge base.

2. Regional structure of the knowledge base

2.1. Analytical framework

The procedure of distinguishing structural dimensions of the knowledge base at the regional level consists of three stages. In the first, the structural aspects of the knowledge base are assigned specified properties, or variables characterising those aspects in the regional approach. In the second, the variables are reduced to dimensions, or significant variables, or components. In the third stage, the structural aspects of the knowledge base, or their systems, are described using the dimensions, and thus the category of structural dimensions of the knowledge base is introduced.

In the first stage, a set of data is created which contains the values of 63 variables characterising the 16 regions (voivodeships) of Poland at the close of the 1990s. The set is then divided into the following subsets (blocks) referring to the structural aspects of the knowledge base distinguished (Table 1):

Table 1

Variable blocks and variables

A. Human resources
1. Population density
2. *Per* cent of urban population
3. Male age median
4. Female age median
5. Males of working age as *per* cent of total population
6. Females of working age as *per* cent of total population
7. Ratio of working to retired population
8. Natural increase *per* 1,000 population
9. Coefficient of demographic dynamics
10. Live births *per* 1,000 women of childbearing age (15-49)
11. Deaths of infants *per* 1,000 live births
12. Male life expectancy
13. Female life expectancy
14. Deaths from circulatory diseases *per* 100,000 population
15. Net internal migration *per* 1,000 population
16. Population of maximum occupational mobility age (proportion of people aged 20-39 in total population of working age)
B. Human capital
17. Working population as % of total population
18. Activity rate (proportion of the working population in the number of population aged 15 and older)
19. Proportion of employed population in the number of population aged 15 and older
20. Unemployment rate
21. Unemployed *per* 1,000 employed population
22. Unemployed with higher education (% total unemployment)
23. Population with primary education as % of population aged 15 and older
24. Population with secondary education as % of population aged 15 and older
25. Population with higher education as % of population aged 15 and older
26. Employment in research and development *per* 1,000 population
C. Social capital
27. Enterprises of natural persons *per* 1,000 population of the working age
28. Enterprises of natural persons and private partnerships *per* 1,000 population
29. Non-governmental social organisations (foundations, associations) *per* 1,000 population
30. Loanable funds
31. Agencies for regional and local development
32. Training/consultative centres
33. Local loanable and guarantee-loanable funds
34. Proportion of investment outlays in total expenditure of commune budgets
35. Voter turnouts in parliamentary elections (%)
D. Knowledge-generating institutions
36. State higher schools
37. Non-state higher schools
38. Students *per* 1,000 population
39. Students *per* academic teacher
40. Academic degrees conferred in higher schools
41. Employment in R&D (Poland = 100)
42. Employment in R&D *per* 1,000 working population
E. Transfer of knowledge
43. Net enrollment in secondary education
44. Gross enrollment in higher education
45. Primary-school pupils taking optional English courses (% of all pupils)
46. Book loans from libraries of scientific institutions and firms *per* 1,000 population
47. Scientific-technological solutions applied in the form of licence agreements in industrial plants
F. Outlays on knowledge generation
48. Outlays for R&D as % GDP
49. Outlays for R&D in zlotys *per* person
50. Outlays for R&D in thousand zlotys *per* employee
51. Proportion of fixed capital investment in outlays for R&D
52. Proportion of state budgetary means in total outlays for R&D
53. Proportion of outlays for basic research in current outlays for R&D
54. Proportion of outlays for applied research in current outlays for R&D
55. Proportion of outlays for developmental work in current outlays for R&D
56. Outlays for innovation in industry *per* industrial worker, in thousand zlotys
G. Level of innovativeness
57. Industrial robots *per* industrial worker
58. Proportion of industrial plants introducing technological innovations
59. Output of new and modernised products *per* industrial worker, in thousand zlotys
60. Proportion of new and modernised products in industrial output sold
61. Proportion of industrial plants using the Internet (Poland = 100)
62. Computers in industrial plants *per* 1,000 industrial workers
63. Proportion of households with personal computers

A. Human resources (variables 1-16)
B. Human capital (variables 17-26)
C. Social capital (variables 27-35)
D. Knowledge-generating institutions (variables 36-42)
E. Transfer of knowledge (variables 43-47)
F. Outlays on knowledge generation (variables 48-56)
G. Level of innovativeness (variables 57-63).

The number of variables in the particular subsets differs. It is not connected with the weight of the given aspect of the structure of the knowledge base, however, but with the availability of statistical data.

In the second stage, significant attributes, or dimensions, of the knowledge base are identified using higher-order principal components analysis (cf. Rummel 1970; Palmer, Robinson, Thomas 1977: 747). The method is applied at two levels of analysis, which leads to a two-tier system of components[1].

At the first level of analysis, the principal components are derived from the original variables, separately for each of the seven subsets (blocks) describing the knowledge base. They are called first-order components. From among the principal components, the first and second are chosen (in the case of block D, exceptionally the first component only) accounting for the largest share of the total variance of the original variables within the individual subsets. In the subsets the first component V_1 accounts for 36% to 68% of total variance, and the second V_2, for 22% to 30% (Table 2). In the analytical approach, the components are super-variables. The particular components show significant correlations with specific original variables, whose number ranges from 2 to 8.

Table 2

Results of principal components analysis

Variable blocks	Percentage of total variance explained by principal components		
	V_1	V_2	$V_1 + V_2$
A	47.6	25.2	72.8
B	45.3	30.1	75.4
C	40.3	21.9	62.2
D	68.1		
E	36.5	23.0	59.5
F	36.0	27.4	63.4
G	40.8	28.3	69.1

[1] The programs „Higher-order principal components analysis" and „Multiple regression model" have been designed and implemented by Jan Hauke.

At the second level of analysis, second-order components are introduced from the set of the first-order components. They are called meta-components. As a result of the transformation of the components at this level, three meta-components have been distinguished, MV1, MV2 and MV3, accounting, respectively, for 36.8%, 22.9% and 12.9% of the variance of the first-order components, that is, a total of 72.6% of the variance. Through the first-order components, the meta-components are correlated with only 24 of the original variables and are their generalisations. In Figure 1, the lines between the higher- and lower-order components show those second-order components (meta-components) with which the first-order components are significantly correlated, while the lines joining the first-order components and the original variables indicate with which original variables the first-order components are significantly correlated.

Owing to its links with components BV_1, CV_1, DV_1, EV_1, FV_1, and GV_1, the first meta-component MV1 is a multi-aspect one, that is, a system of six aspects of the knowledge base: human resources, social capital, knowledge-generating institutions, transfer of knowledge, outlays on knowledge generation, and the level of innovativeness (Fig. 2). In the first meta-component MV1, each of these aspects is represented by only those variables which are contained in the components showing significant correlations with the meta-component MV1. These variables are generalised with relation to the particular aspects of the knowledge base in the following way:

(1) total working population and employment in research and development (representing the human capital aspect),
(2) the population's economic and social activity (representing the social capital aspect),
(3) the operation of higher schools and R&D institutions (representing the knowledge-generating-institutions aspect),
(4) the extent of higher education in society and the practical implementation of knowledge (representing the transfer-of-knowledge aspect),
(5) outlays for R&D and their internal structure (representing the outlays-on-knowledge-generation aspect), and
(6) modern manufacturing (representing the level-of-innovativeness aspect).

The second meta-component MV2 represents only one aspect of the knowledge base: human resources. It shows a significant correlation with component AV_2, which in turn is strongly connected with two variables characterising demographic youth.

The third meta-component MV3 can be interpreted, through its correlation with component GV_2, in terms of information and technological progress in manufacturing, hence it complements the characterisation of the innovativeness level as an aspect of the knowledge base.

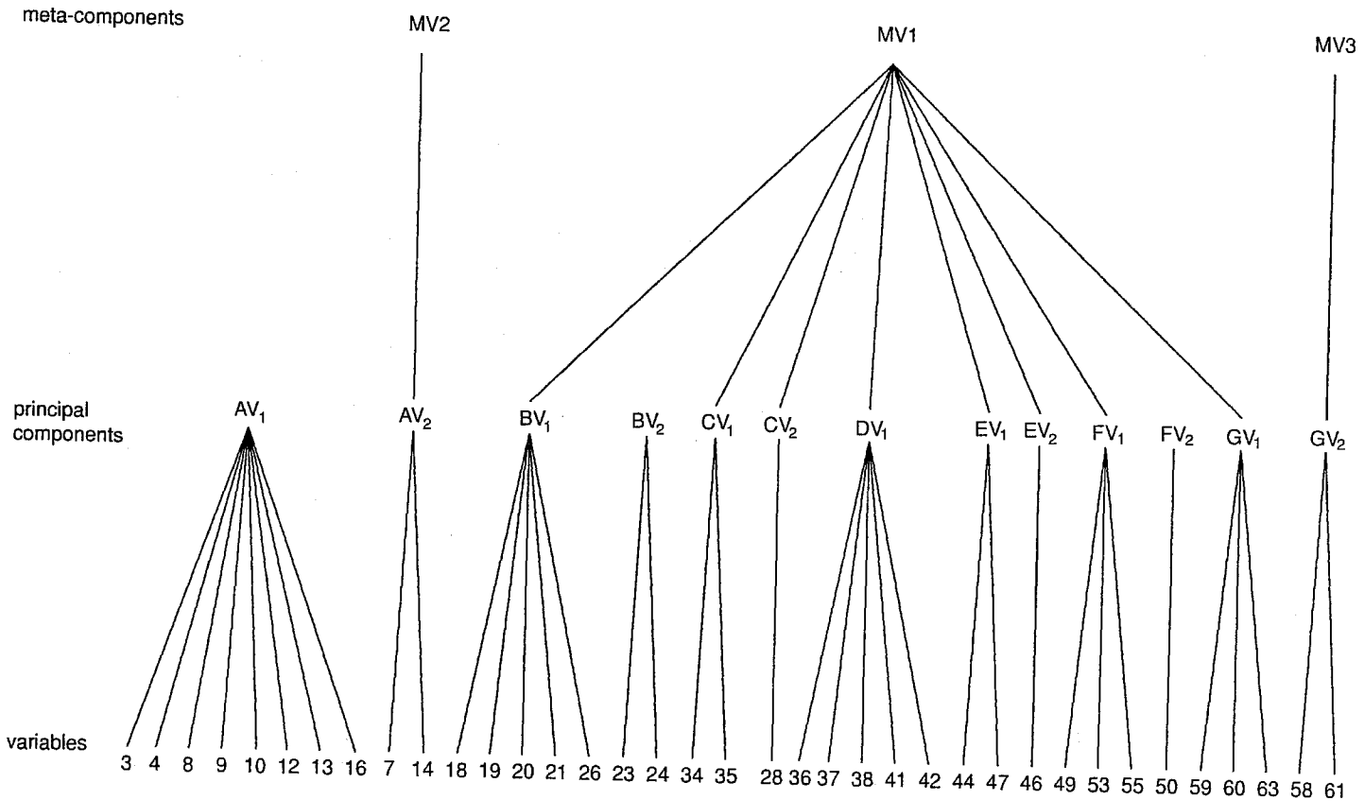

Fig.1. Higher-order components analysis

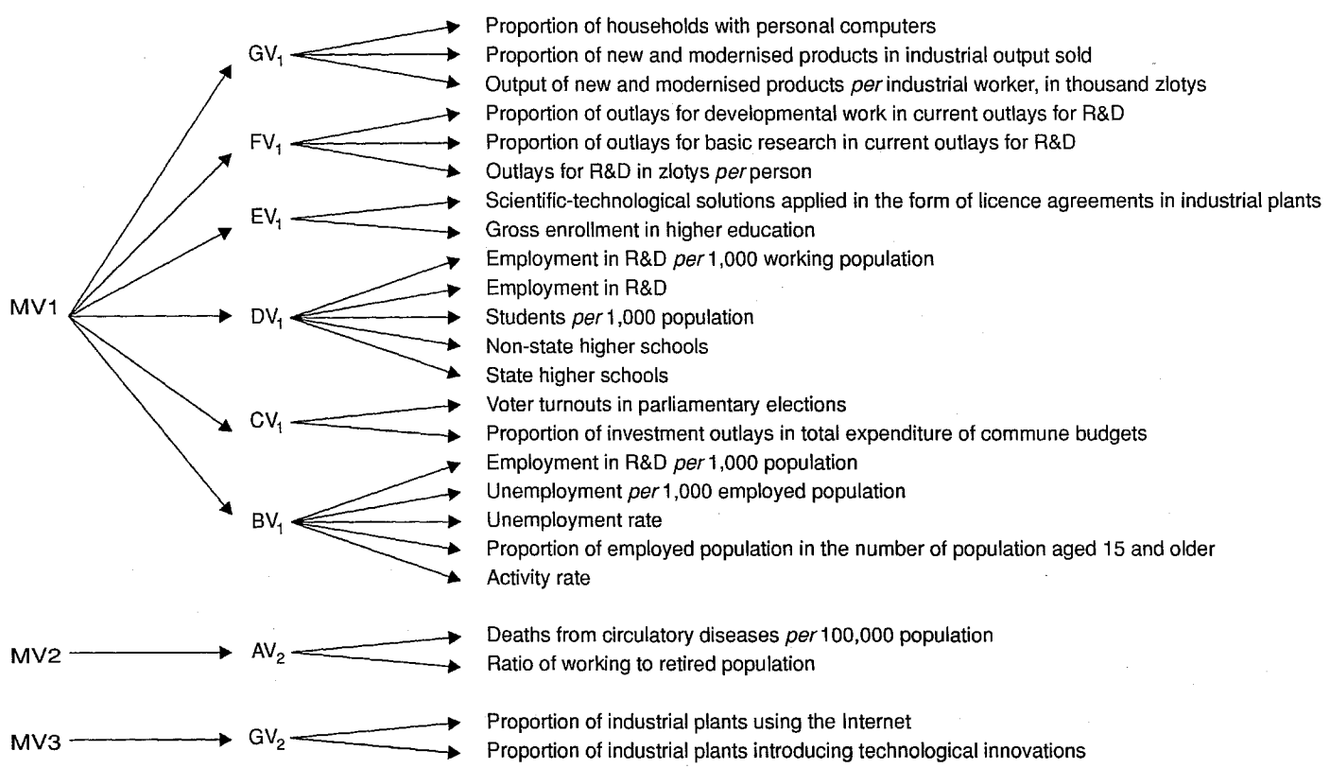

Fig. 2. Structure of meta-components

In the third stage of the procedure, structural dimensions of the knowledge base are identified. The analysis of the complexity of the meta-components shows that the main structural dimension of the knowledge base is the first, multi-aspect, meta-component MV1. The other two are single-aspect structural dimensions of the knowledge base. The first meta-component is interpreted as 'development of the knowledge base'; the second, 'the scale of demographic youth and old age'; and the third, 'information and technological progress in industry'.

2.2. Differences in the knowledge base in the regional approach

The values of the meta-components are synthetic characteristics of the knowledge base; they provide a basis on which regional differences in the base are determined. The spatial distribution of the values of the first meta-component MV1, understood as 'development of the knowledge base', is presented in Fig. 3. Its analysis allows a dichotomous division of Poland into regions with well- and poorly developed knowledge base. The first group embraces Mazovia, Małopolska, Wielkopolska, Lower Silesia, Pomerania, Łódź, and Silesia; and the other group, the remaining nine voivodeships. It

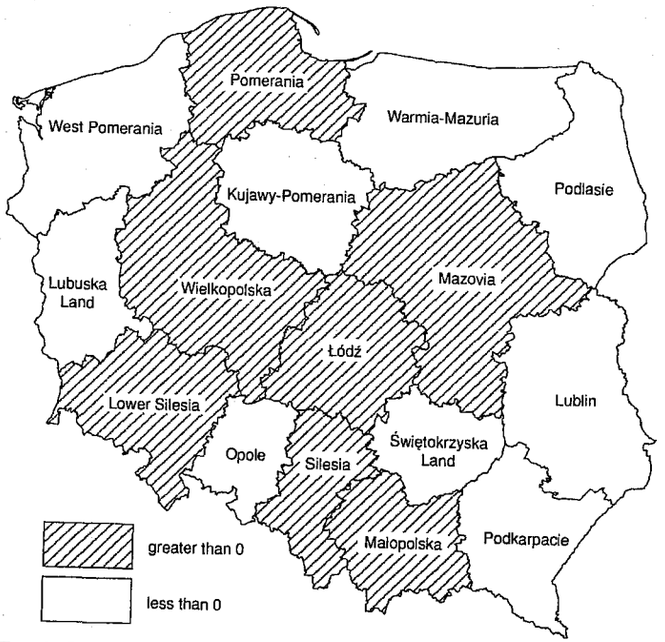

Fig. 3. Spatial distribution of values of the first meta-component

should be noted that the regions in the first group are those with large metropolitan areas. The classification of regions made on the basis of values of the three meta-components, employing the dichotomous criterion of division (positive and negative standardised values), is presented in Table 3.

The position of the regions on the scale of the first meta-component MV1 is compared with that on the scale of the sum of weighted values of all three meta-components (MV1, MV2, MV3). The weight of a region's scores for each meta-component is expressed by the proportion of total variance explained by that meta-component. The comparison leads to the conclusion that differences in the human resources aspect (the ageing of the population, which is not favourable to innovativeness, MV2) and in the innovativeness level (effects of innovation in manufacturing, MV3) bring about changes in the classification of regions (Table 4). While Mazovia, Lower Silesia, Pomerania, Kujawy-Pomerania, Świętokrzyska Land, and Warmia-Mazuria retain their positions, Silesia, West Pomerania, Opole, Lubuska Land, and Podkarpacie go up, and Wielkopolska, Małopolska, Łódź, Lublin, and Podlasie go down.

Table 3

Classification of regions in terms of the knowledge base

Class	MV_1	MV_2	MV_3	Interpretation	Regions
I	+	+	+	well-developed knowledge base, demographic youth, great information and technological progress in industry	Lower Silesia, Silesia
II	+	+	–	well-developed knowledge base, demographic youth, poor information and technological progress in industry	Pomerania, Wielkopolska
III	+	–	–	well-developed knowledge base, demographic ageing, poor information and technological progress in industry	Łódź, Małopolska, Mazovia
IV	–	+	+	poorly developed knowledge base, demographic youth, great information and technological progress in industry	Kujawy-Pomerania, Lubuska Land, Opole
V	–	–	+	poorly developed knowledge base, demographic ageing, great information and technological progress in industry	Podkarpacie, Świętokrzyska Land
VI	–	+	–	poorly developed knowledge base, demographic youth, poor information and technological progress in industry	Warmia-Mazuria, West Pomerania
VII	–	–	–	poorly developed knowledge base, demographic ageing, poor information and technological progress in industry	Lublin, Podlasie

Table 4

Ordering of regions on the scale of meta-components

Value of meta-component MV1	Sum of weighted values of meta-components MV1, MV2 and MV3
Mazovia	Mazovia
Małopolska	Silesia
Wielkopolska	Lower Silesia
Lower Silesia	Pomerania
Pomerania	Wielkopolska
Łódź	Małopolska
Silesia	West Pomerania
Lublin	Lubuska Land
West Pomerania	Opole
Podlasie	Kujawy-Pomerania
Kujawy-Pomerania	Łódź
Opole	Podkarpacie
Lubuska Land	Lublin
Podkarpacie	Świętokrzyska Land
Świętokrzyska Land	Warmia-Mazuria
Warmia-Mazuria	Podlasie

2.3. Relations between economic performance and the knowledge base in the regional approach

In terms of economic performance as measured by *per capita* GDP in 1999, the regions (voivodeships) of Poland can be divided into three classes: strong (5 regions), average (6), and weak (5) (Fig. 4). The differences in the regional income *per* head range from 70% (Lublin) to 149% (Mazovia) of the national mean. Regional contrasts in Poland are comparable with those in many countries of the integrating Europe, but at a much lower level of development. In 1999 *per capita* income in Poland equalled 39% of average income in the European Union states. The index varied between 27% (Lublin) and 58% (Mazovia) of the EU regional mean. The average annual growth rate of *per capita* GDP for regions over the period 1995-2000 (with Poland = 100) ranged from a high of 124% for Mazovia (with strong economic performance) to a low of 114% for the Lublin region (with low performance), which is evidence of persistent regional contrasts at the scale of the country.

The study of the relation between a region's economic performance and its knowledge base consists in establishing the dependence between the region's economic index (*per capita* income) and the structural aspects of the

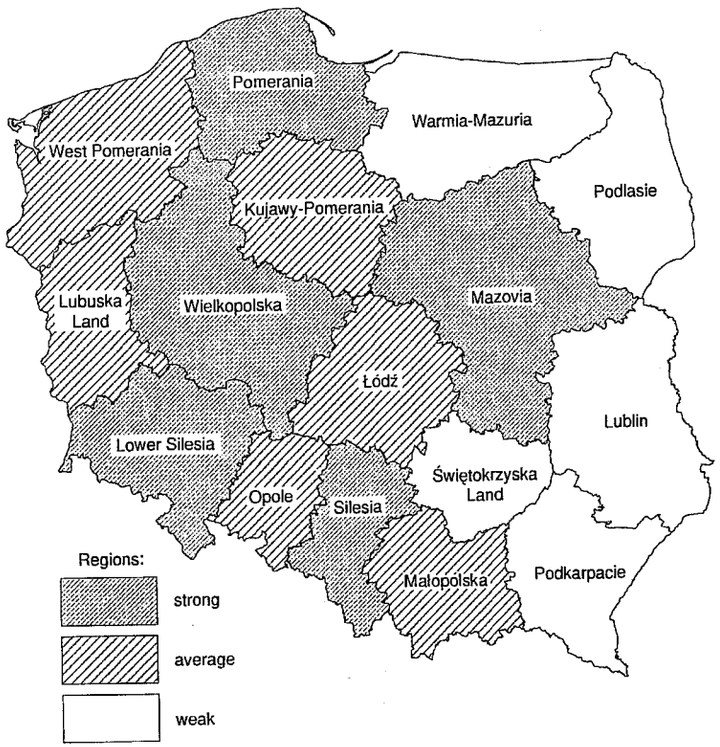

Fig. 4. Strong, average and weak regions in Poland

knowledge base in the region. The structural aspects are represented by the three broad meta-components outlined above, which compress in themselves 24 significant original variables describing the base. The regression model that serves to test the hypothesis about the role of the knowledge base in determining the regions' economic performance assumes the following form:

$$y_j = b_0 + b_1 s_{1j} + b_2 s_{2j} + b_3 s_{3j}$$

where:

y_j = *per capita* GDP in region j,

s_{1j}, s_{2j}, s_{3j} = meta-component scores of region j on MV1, MV2 and MV3.

The dependence of each region's *per capita* GDP on their scores of the three meta-components is expressed in the form of a regression model. The results of this regression, estimated by the least-squares method, are presented in the following equation:

$$y = 14.712 + 2.698^{**} s_1 + 1.220^{*} s_2 + 0.359 s_3$$

** significant at the $\alpha = 0.0001$ level
* significant at the $\alpha = 0.0005$ level

Only two out of the three meta-components are significant statistically and account for 92% of the variance of variable *y*, i.e. *per capita* income. The significant and positive regression coefficients of meta-components MV1 and MV2 show that the better developed a region's knowledge base, the stronger its economic performance. However, residuals from regression calculated from this equation reveal regional deviations from this relation. Significant negative residuals are obtained for regions with a rather low income level in relation to their knowledge base. Those regions include Małopolska, Lublin, and Pomerania. Significant positive residuals denote a higher income level than the one implied by its relation with the knowledge base. Positive residuals are recorded in Świętokrzyska Land, Silesia, and Wielkopolska.

The regions whose economic performance is not proportional to their knowledge base belong to three classes of development. Pomerania (from the class of strong regions), Małopolska (from the average class) and Lublin (from the weak class) have scientific and academic centres and a relatively big potential for scientific and educational activity (cf. Chojnicki, Czyż 1997: 81), but their knowledge base has a rather weak effect on their economies.

The higher regional income in relation to the knowledge base in Silesia and Wielkopolska can be explained not only by the development of their knowledge base, but also by the use of extensive factors of production (labour, raw materials, energy) in the process of their economic growth. In the case of Świętokrzyska Land, the 'excess' of economic performance of this weak, poorly industrialised region with a weak knowledge base is connected with the fact that innovation transfer takes place in only a few of its industrial plants *via* foreign direct investment and links with abroad (Domański 2001: 86).

* * *

In Poland during the transformation period, the chances of the regions for development based on knowledge differ widely. According to Meusburger (2002: 301), „regional disparities of knowledge have a cumulative and self-enforcing effect". A poorly developed, regionally diversified knowledge base explains to an extent why some regions in Poland have emerged from the transformation as winners and some as losers. As Meusburger observes (2002: 302), „Knowledge alone does not suffice, it is only one of many factors influencing economic competitiveness. Knowledge enables and empowers, it is a kind of precondition for the effectiveness of other factors. Knowledge is

by no means a guarantee of economic success, but a lack of knowledge, information and educational attainment in most cases leads to wrong decisions, impedes access to privileged positions, important networks and scare resources, and is an obstacle to modernisation".

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