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Assessment of Connections Between Knowledge- Based Economy Characteristics and Selected Macroeconomic Categories in the European Union's Countries by Means of Panel Models

Abstract

Directions of changes occurring in the world economy in recent years show the transformation of the industrial economy into a knowledge-based economy, using the technological and innovative potential. The most vital determinants of economic development are research and development expenditures, effects of this activity revealed in the form of innovations and human capital. Consequently the main subject of research conducted in high developed countries is seeking new sources of innovativeness and methods of creating innovative potential. An essential impact of knowledge and innovations on economic development is also confirmed by the contemporary economics.

The aim of the article is to analyze the impact of knowledge-based economy variables on the selected macroeconomic categories – the share of total investments in GDP and the employment rate- in European Union`s countries in the years 2000-2007, conducted with application of panel models.

1. Introduction

The process of transition to knowledge-based economy (KBE) appears in the increase in competitive advantage of countries and regions specializing in

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manufacturing high-tech products. Research and development (R&D), innovation activity and the so-called human capital become decisive factors for economic development. Consequently the target of research run in highly developed countries is searching for sources of innovation and methods of building innovation potential which become the basis of creating knowledge-based economy (Miedziński 2001, p. 210).

The essential impact of knowledge and innovation on economic development is confirmed by modern economics. Nevertheless we owe the increase of interest of economic theories in innovation process to J. A. Schumpeter who as the first of the great economists in the first half of the twentieth century created modern bases of innovation theories and recognized them as the key factor of economic development (Schumpeter 1912). Then in the second half of that century two approaches emphasizing the role of knowledge and innovation in economic growth were developed, namely the neoclassical approach basing on the Solow model (Solow 1957) and the endogenous one within its framework should be mentioned among others: J. Schmookler`s concept of demand sources of innovation (Scmookler 1965), F. Machlup`s concept of knowledge production (Machlup 1962), models of P. M. Romer (Romer 1993), R. E. Lucas (*Foundations of the Economics of Innovation. Theory, Measurement and Practice* 1998), W. D. Nordhaus (Nordhaus 1976), and also analyses of G. Grossman and E. Helpman (Grossman, Helpman 1990,1991), D. T. Coe (Coe 1995), M. Porter (Porter 1990), J. Fagerberg (Fagerberg 1987) and D. Jorgenson (Jorgenson 2001; Jorgenson, Ho, Stiroh 2003). These theories confirm that technological progress as well as accumulation of scientific and technological knowledge and human capital affect development of modern economies in a bigger degree than traditional production factors.

The objective of the article is an analysis of the impact of variables describing knowledge – based economy on basic macroeconomic categories (the share of total investments in GDP and the employment rate) in the European Union`s countries (dividing them into the EU-15 and the new EU` member states) in the period 2000-2007, conducted by means of panel models.

2. Methodology of research

Panel models are constructed on the basis of panels, that is cross-time samples covering data for the same objects in different time units. The construction of classical models based on this type of samples is connected with the risk of heteroskedasticity appearance, meaning that the random component variance is not constant which results in the fact that structural parameter estimator (estimated by means of the least squares method) is not effective. This problem is re-absorbed in panel regression. The application of panel approach also facilitates taking into consideration specifity of each state and assessing differences between countries – by means of the so – called estimation of constant effects in panel equations (Hsiao 1986).

Panel models can take the following form:

- models with decomposition of the free term (FEM – Fixed Effects Model)

or

- models with decomposition of the random component (REM – Random Effect Model),

when the decomposition can take into account only one factor (one-factor models) or two factors simultaneously (two – factor models).

The models FEM and REM can be recorded in the following way:

$$y_{it} = \mu_i + \beta x_{it} + \varepsilon_{it} \quad (1)$$

where μ_i – free term, β – structural parameter expressing in the impact of explanatory variable X, x_{it} – realization of the explanatory variable for i-of this object in t-of this period, e_{it} – remainders fulfilling the classical assumption: $E(\varepsilon_{it}) = 0$ i $var(\varepsilon_{it}) = S_e^2$.

In the FEM model μ_i is decomposed into free terms (constant) for particular groups (in this case countries) separately. The model has then the following form (Greene 2003, p. 285):

$$y_{it} = \alpha_i + \beta x_{it} + \varepsilon_{it}, \quad (2)$$

where α_i – specific free terms, when the parameter α_i corresponds with zero-one variable, ta king value 1 for i- of this object. The model obtained in this way is defined as LSDV – *Least Squares Dummy Variables Model*, and its parameters can be estimated by classical methods (Greene 2003, p. 285).

In the REM model μ_i expresses specific random components. This model can be recorded in the following way (Greene 2008, p. 290):

$$y_{it} = \alpha + \beta x_{it} + u_i + \varepsilon_{it}, \quad (3)$$

where $E(u_i) = 0$, $var(u_i) = S_e^2$, $cov(\varepsilon_{it}, u_i) = 0$. Parameters of such a model can be estimated by generalized least squares method (generalized least squares – GLS).

The evaluation of the panel model is based on the chi-square statistics which bases on the Likelihood Ratio Test and on F statistics (counted traditionally on the basis of sum squared deviations), for the REM model

Lagrange Multiplier Test is conducted, its test statistic is Lagrange Multiplier Test Statistic. With low test likelihood p (smaller than customarily accepted level of significance – 0,05) the reason for free term decomposition or random component is recognized. The choice between the model FEM and REM is conducted by means of the Hausman test (with $p<0,05$ the FEM model is considered as more reliable than REM) (Hausman 1978).

For these considerations both decomposition models with free term and decomposition with random component – one- and two- factor models were constructed. Verification of the designed equations applying the above discussed tests showed significance of group effects both in relation to the EU 24 states (in one-factor models) as well as years (in two- factor models), however, being guided by the essential premises (the objective of the research was above all proving differences for individual EU` member states), as well as statistical ones (bigger number of freedom levels), concluding was limited to one-factor models. Basing on the results of Hausman test it was confined to the models with decomposition of free term.

To estimate parameters of the models the software Limdep 7.0 was applied.

3. Analysis of cause-result relations between knowledge-based economy variables and selected macroeconomic categories in the European Union's countries

In this chapter are presented findings of analysis directed at defining general for the 24 European Union states tendencies towards changes in basic macroeconomic dimensions in the period 2000-2007[1]. To meet the target was made to construct panel regression function in which as explanatory variables were accepted particular knowledge-based economy characteristics representing its three spheres: (A) Science and technology, (B) Education and trainings, (C) Information society[2]. These spheres can be considered as the most essential ones from the point of view of knowledge-based economy description. Similar spheres were separated in government documents, among others "Directions for

[1] Due to incomplete data the analysis was limited to the 24 European Union`s countries; Cyprus, Malta and Luxemburg were excluded from it. These countries are so small that their results can be recognized as weakly representative of the whole European Union.

[2] It should be emphasized that the research applied all the variables published in *Eurostat*, belonging to the mentioned knowledge-based economy sphere, values of which were available for the period 2000-2007.

the increasing innovativeness of the economy for the period 2007-2013", in which the following pillars of knowledge-based economy were separated: (a) High tech industries, (b) Science and research resources, (c) Education, (d) Knowledge intensive business services and (e) Information society services[3]. It turn as explained variables in the research the following macroeconomic categories were recognized:

- the share of total investments in GDP,
- the employment rate.

Accepting the years 2000 as the beginning of the analysed period is connected with publication of the Lisbon Strategy in which as the main direction of the EU's development was recognized making by 2010 the Union economy the most competitive in the world knowledge-based economy characterized by bigger than hitherto degree of social cohesion and giving more jobs. It can be, then, stated that accepting the Lisbon strategy by the Union countries accelerated the process of building knowledge-based economies[4]. Referring to finishing the period of analysis in 2007 it should be emphasized that published by *Eurostat* statistics do not cover later years, moreover at the moment of conducting the analysis some of time series finished in 2006. Consequently for the lacking variables their approximate values in 2007 were found on the basis of trend function. It was possible thanks to long enough time series (in the assessment of these function were included data since 1996). The analysis was conducted in two stages. In the first one the estimate for the whole group of 24 EU countries (models A) was obtained. It was conducive to separating general tendencies of changes for the European Union. As analyzing correlations between the studied phenomena on the level of individual countries quite clear differences were noted, in the second stage of the analysis models were constructed analogous to the first stage, but this time separately for the new member states (models B) and the EU 15 countries (models C). In this research the sample covered the data for the period 2000-2007 respectively for 24 (models A), 14 (models B) and 10 (models C) countries of the European Union. All the models were examined by means of LRT and F test which – for each of the discussed here equations – confirmed significance of the group effects and thus justification of the free

[3] It is worth emphasizing that a few variables belonging to the pillar "Science and technology" (considered in the research) represent the spheres of "High-tech industry" and "Knowledge intensive business services" separated in "Directions for increasing innovativeness of economy for the period 2007-2013", the Ministry of Economy, Department of Economic Development, Warsaw 19th August 2006, p. 6.

[4] The idea of „knowledge-based economy" appeared already in 1996 in documents of OECD. Cf. "The Knowledge-Based Economy", OECD, Paris 1996.

terms decomposition for particular countries. Having in mind the accepted framework of the publication these results are not included in the later discussed tables. The presentation of the findings was limited to basic characteristics of the model, which – considering the analysis objective that is only defining cause – result correlations between knowledge-based economy characteristics and selected macroeconomic categories – seems well-founded.

In table 1 (and the remaining ones) highlighted in beige are these variables whose influence on the examined indicator (e.g. the share of total investments in GDP) is positive and statistically significant, while highlighted in blue are the variables whose impact on macroeconomic category is negative and statistically significant.

The first macroeconomic category examined in the model are investments made in economy. The following equations for the share of total investments in GDP (as percentage of GDP) (tables 1, 2). On the basis of the outcomes shown in table 1 it can be stated that the estimated model (1) is conducive to explaining the share of investments in GDP in somewhat less than 80%, while model (2) is almost 60%. On the level of the 24 EU countries a significant, positive impact on the level of investments is made especially by R&D expenditures (the share of total budget expenditures of GDP and expenditures per capita – not including expenditures of industry (of enterprises). This impact is the following:

- the increase in R&D budget expenditures in GDP of 1 percentage point is conducive to the increase in the share of investments of almost 9.5 percentage points,
- the increase in the share of R&D expenditures in GDP of 1 percentage point results in the increase of investments share in GDP by more than 4 percentage points,
- the increase in total R&D expenditures per capita of € 1 results in increasing the share of investments of 0,008 percentage point.

A similar situation occurs in case of patent applications filed by EPO[5] (per million population), and also in labour force resources in science and technology.

[5] EPO – European Patent Office.

Table 1. Structural parameters and parameters of stochastic structure of models describing the share of total investments in GDP dependent on the selected KBE characteristics for 24 UE countries

Number of model	The explanatory variable	The explanatory variable: **The share of total investments in GDP**			
		Regression coefficient	statistics t	p	R^2
1a	Share of R&D expenditures in GDP	4,068	4,425	0,0000	0,7828
1b	Government R&D expenditures as a percentage of GDP	9,477	3,641	0,0003	0,7744
1c	Gross R&D expenditures in euro	0,008	2,738	0,0068	0,7672
1d	Gross R&D expenditures (GERD) financed by industry as a percentage of GERD	0,015	0,421	0,6742	0,7568
1e	Exports of high technology products as a percentage of total exports	-0,151	-2,273	0,0242	0,7638
1f	High-technology trade per capita in 1000 euro	-0,395	0,292	0,7704	0,7538
1g	European high-technology patents per million inhabitants	-0,009	-0,556	0,5790	0,7570
1h	Patent applications to the European Patent Office per million inhabitants	0,029	2,030	0,0437	0,7624
1i	Human resources in science&technology as a percentage of labour force	0,232	4,366	0,0000	0,7815
1j	Employment in knowledge-intensive service sectors as a percentage of total employment	0,178	1,281	0,2017	0,7589
1k	Employment in high-and medium-high technology manufacturing sectors as a percentage of total employment	-0,316	-1,294	0,1973	0,7589
1l	Science &technology graduates per 1000 of population aged 20-29	0,031	0,396	0,6926	0,7567

1m	School expectancy	0,902	4,001	0,0001	0,7778
1n	Median age in years	1,958	4,291	0,0000	0,7807
1o	Four-years-olds in education (participation rate - %)	0,123	3,588	0,0004	0,7739
1p	Students per 1000 inhabitants	0,170	4,938	0,0000	0,7875
1q	Foreign languages learnt per pupil	0,987	0,724	0,4700	0,7573
1r	Public expenditures on education as a percentage of GDP	-1,418	-2,830	0,0052	0,7676
1s	Participation in education	0,029	0,361	0,7186	0,7567
1t	18-years-olds in education	0,135	5,131	0,0000	0,7900
1u	Mathematics, science &technology graduates per 1000 of population aged 20 -29	0,062	0,680	0,4972	0,7572
1w	Internet access per 100 inhabitants	-0,015	-0,519	0,6045	0,7569
1x	Number of mobile phone subscriptions per 100 inhabitants	0,039	7,068	0,0000	0,8126

Source: own calculations based on Eurostat data.

Also variables characterizing the sphere of “Education and trainings” in the majority show a positive impact on the incurred investment expenditures – these are median of age, the number of years spent on education the share of four- and eighteen- year olds in education and the number of students per 1000 population. It does not concern, however, contrary to expectations – the number of science and engineering as well as mathematics graduates. In case of these variables the impact on investments is not significant statistically, it may result from the inappropriate use of these graduates’ potential in economy or from their qualifications incoherent with needs of economy. A positive (and statistically significant) impact on the share of investments in GDP is made by the number of mobile phones. Whereas the impact of public expenditures on education turns out to be negative. In spite of comparable to the EU 15 share of these expenditures in GDP in the absolute approach (counted per 1 student) they are decisively lower in the new member countries. For example in Bulgaria the average expenditures per student accounted only for € 2139, in Lithuania and Slovakia they did not exceed three thousand euros, while in Austria and the United Kingdom – about 8 thousand euros and in Denmark even about 14 thousand[6]. Moreover, the increase rate of these expenditures in the group of new members of the EU was lower than in the EU-15.

It is worth emphasizing that in case of investments the influence of knowledge-based economy variables is significant – in relation to most characteristics – in the group of new members of the EU (table 2). A positive impact on the level of investments is exerted both by expenditures on research and development activity (similarly earlier – it does not concern only expenditures financed by industry), human resources in science and technology as well as patent activity (the number of application filed by the EPO), and most characteristics from the sphere of “Education and trainings”.

For the EU-15 the correlation between a few characteristics of knowledge-based economy from the sphere of “Science and technology” (R&D expenditures financed by industry (enterprises), the share of high-tech exports in total export or the share of employment in intensive knowledge services in total employment) and investments is negative. However, it should be noticed that knowledge-based economy development – especially in the sphere of research and development (also financed by the sector of enterprises) is in the EU-15 far more advanced and which is connected with it may be weakly reflected in changes of macroeconomic category. There is also a negative correlation between investments and science & engineering, mathematic graduates, the number of foreign languages and mobile phones.

[6] Eurostat.

Table 2. Structural parameters and parameters of stochastic structure of models describing the share of total investments in GDP dependent on the selected KBE characteristics for new EU`s members and EU-15

Number of model	The explanatory variable	EU-15				New EU` s members			
		b	t-stat	p	R^2	b	t-stat	p	R^2
2a	Share of R&D expenditures in GDP	-0,388	-0,327	0,7445	0,8821	11,217	3,728	0,0040	0,6419
2b	Government R&D expenditures as a percentage of GDP	5,281	2,810	0,0059	0,8915	19,771	3,143	0,0024	0,6236
2c	Gross R&D expenditures in euro	0,007	2,264	0,0255	0,8883	0,036	2,606	0,0109	0,6083
2d	Gross R&D expenditures (GERD) financed by industry as a percentage of GERD	-0,232	-4,832	0,0000	0,9063	0,049	0,930	0,3554	0,5751
2e	Exports of high technology products as a percentage of total exports	-0,187	-3,014	0,0032	0,8928	-0,165	-1,077	0,2849	0,5769
2f	High-technology trade per capita in 1000 euro	-0,060	-0,304	0,7614	0,9249	3,696	0,629	0,5314	0,5722
2g	European high-technology patents per million inhabitants	0,006	0,482	0,6305	0,8823	0,369	0,904	0,3686	0,5748
2h	Patent applications to the European Patent Office per million inhabitants	0,008	0,793	0,4295	0,8828	0,108	2,708	0,0083	0,6076
2i	Human resources in science&technology as a percentage of labour force	0,267	2,395	0,0183	0,8890	0,311	3,339	0,0013	0,6296
2j	Employment in knowledge-intensive service sectors asa percentage of total employment	-0,372	-1,975	0,0508	0,8869	0,623	1,831	0,0709	0,5897

2k	Employment in high-and medium-high technology manufacturing sectors as a percentage of total employment	-0,163	-0,841	0,4021	0,8829	-0,826	-1,377	1,725	0,5813
2l	Science &technology graduates per 1000 of population aged 20-29	-0,200	-3,059	0,0028	0,8931	0,242	1,723	0,0888	0,5875
2m	School expectancy	0,174	0,948	0,3454	0,8832	2,111	4,730	0,0000	0,6751
2n	Median age in years	1,220	3,038	0,0030	0,8930	3,240	3,531	0,0007	0,6356
2o	Four-years-olds in education (participation rate - %)	-0,019	-0,724	0,4707	0,8827	0,333	4,894	0,0000	0,6806
2p	Students per 1000 inhabitants	0,005	0,096	0,9236	0,8820	0,220	4,313	0,0000	0,6611
2q	Foreign languages learnt per pupil	-2,968	-3,402	0,0009	0,8954	11,630	3,244	0,0017	0,6267
2r	Public expenditures on education as a percentage of GDP	0,218	0,520	0,6040	0,8823	-2,743	-2,894	0,0049	0,6163
2s	Participation in education	0,009	0,178	0,8592	0,8820	-0,182	-0,506	0,6140	0,5713
2t	18-years-olds in education	0,025	0,736	0,4633	0,8827	0,176	4,320	0,0000	0,6613
2u	Mathematics, science &technology graduates per 1000 of population aged 20 -29	-0,367	-4,819	0,0000	0,9062	0,424	2,424	0,0176	0,6035
2w	Internet access per 100 inhabitants	0,010	0,478	0,6334	0,8823	-0,175	-1,792	0,0769	0,5889
2x	Number of mobile phone subscriptions per 100 inhabitants	-0,048	-2,177	0,0316	0,8879	0,051	6,414	0,0000	0,7304

Source: own calculations based on Eurostat data.

In table 3 there are presented structural parameters and stochastic structures of models describing the impact of particular knowledge-based economy characteristics on the employment rate estimated on the basis of the sample for the 24 EU countries whereas in table 4 are shown the parameters of the models describing the employment rate according to the selected knowledge-based economy characteristics of the new member countries and the EU-15.

Table 3. Structural parameters and parameters of stochastic structure of models describing the employment rate dependent on the selected KBE characteristics for 24 UE countries

Number of model	The explanatory variable	The explanatory variable: The employment rate			
		Regression coefficient	Statistics t	p	R^2
3a	Share of R&D expenditures in GDP	7,469	5,635	0,0000	0,9305
3b	Government R&D expenditures as a percentage of GDP	9,571	3,876	0,0001	0,9241
3c	Gross R&D expenditures in euro	0,016	6,238	0,0000	0,9333
3d	Gross R&D expenditures (GERD) financed by industry as a percentage of GERD	0,088	2,662	0,0084	0,9207
3e	Exports of high technology products as a percentage of total exports	-0,167	-2,651	0,0087	0,9206
3f	High-technology trade per capita in 1000 euro	0,376	0,296	0,7678	0,9205
3g	European high-technology patents per million inhabitants	-0,031	-1,954	0,0522	0,9191
3h	Patent applications to the European Patent Office per million inhabitants	0,046	3,523	0,0005	0,9230
3i	Human resources in science&technology as a percentage of labour force	0,205	4,004	0,0001	0,9245
3j	Employment in knowledge-intensive service sectors as a percentage of total employment	0,446	3,479	0,0006	0,9229
3k	Employment in high-and medium-high technology manufacturing sectors as a percentage of total employment	-0,148	-0,636	0,5257	0,9175
3l	Science &technology graduates per 1000 of population aged 20-29	0,124	1,686	0,0935	0,9187

3m	School expectancy	0,281	6,335	0,0000	0,9333
3n	Median age in years	2,236	5,269	0,0000	0,9291
3o	Four-years-olds in education (participation rate - %)	0,113	3,439	0,0007	0,9228
3p	Students per 1000 inhabitants	0,185	5,739	0,0000	0,9309
3q	Foreign languages learnt per pupil	2,968	2,315	0,0217	0,9199
3r	Public expenditures on education as a percentage of GDP	-1,497	-3,151	0,0019	0,9219
3s	Participation in education	-0,084	-1,122	0,2634	0,9179
3t	18-years-olds in education	0,169	7,188	0,0000	0,9368
3u	Mathematics, science &technology graduates per 1000 of population aged 20 -29	0,304	3,647	0,0003	0,9234
3w	Internet access per 100 inhabitants	-0,066	-2,382	0,0182	0,9200
3x	Number of mobile phone subscriptions per 100 inhabitants	0,497	11,029	0,0000	0,9521

Source: own calculations based on Eurostat data.

It is essential that all of the estimated equations in the model (3) are characterized by high degree of explanation of the employment rate variability – determination coefficients are of the value above 0,9, which means that the application of panel regression was conducive to explaining more than 90% of the phenomenon variability. Model (4) is characterized by much lower adjustment than model (3) and is conducive to explaining the employment rate in somewhat less than 80%.

On the level of the EU 24 a profitable impact (statistically significant) on the employment rate is exerted by R%D expenditures (the share of R&D expenditures in GDP, the share of R&D budget expenditures in GDP, R&D expenditures per capita as well as the share of R&D expenditures financed by industry), human resources in science and technology, also employment in intensive knowledge services and patent activity (the number of patent applications filed by EPO). As it was expected the employment rate is an increasing function of educational system development – the majority of variables from the “Education and training” sphere show a positive (statistically significant) correlation with the employment rate, the employment rate increases considerably with growing number of mobile phones. A negative correlation occurs between the employment rate and high-tech export (its share in total export), the number of European high-tech patents, public expenditures on education and broadband access.

On the basis of outcomes shown in table 4, averaging for all the EU (after excluding Malta, Cyprus and Luxemburg) – it can be stated that discussed regularities are especially clear in the new member countries, much weaker regularities occur in the EU-15.

Table 4. Structural parameters and parameters of stochastic structure of models describing the share of the employment rate dependent on the selected KBE characteristics for new EU`s members and EU-15

Number of model	The explanatory variable	EU-15				New EU`s members			
		b	t-stat	p	R^2	b	t-stat	p	R^2
4a	Share of R&D expenditures in GDP	1,958	1,817	0,0719	0,9737	11,653	4,487	0,0000	0,8037
4b	Government R&D expenditures as a percentage of GDP	6,184	3,663	0,0004	0,9762	9,046	1,528	0,1305	0,7547
4c	Gross R&D expenditures in euro	-0,001	-0,049	0,9612	0,9729	0,059	5,470	0,0000	0,8231
4d	Gross R&D expenditures (GERD) financed by industry as a percentage of GERD	-0,109	-2,265	0,0255	0,9742	0,117	2,611	0,0108	0,7692
4e	Exports of high technology products as a percentage of total exports	0,009	0,148	0,8824	0,9727	-0,041	-0,297	0,7673	0,7467
4f	High-technology trade per capita in 1000 euro	-0,202	-0,262	0,7940	0,9753	3,267	0,0621	0,5365	0,7478
4g	European high-technology patents per million inhabitants	0,010	0,971	0,3336	0,9730	0,638	1,776	0,0796	0,7575
4h	Patent applications to the European Patent Office per million inhabitants	0,001	0,014	0,9889	0,9727	0,180	3,222	0,0018	0,7796
4i	Human resources in science&technology as a percentage of labour force	0,067	0,637	0,5253	0,9728	0,104	1,164	0,2481	0,7513

4j	Employment in knowledge-intensive service sectors as a percentage of total employment	0,208	1,181	0,2401	0,9731	-0,034	-0,110	0,9123	0,7465
4k	Employment in high-and medium-high technology manufacturing sectors as a percentage of total employment	0,174	0,975	0,3315	0,9730	-0,826	-1,377	0,1725	0,5813
4l	Science &technology graduates per 1000 of population aged 20-29	0,077	1,223	0,2241	0,9731	0,239	1,917	0,0589	0,7592
4m	School expectancy	0,431	2,623	0,0100	0,9746	2,161	5,703	0,0000	0,8277
4n	Median age in years	0,675	1,763	0,0807	0,9736	2,868	3,486	0,0008	0,7844
4o	Four-years-olds in education (participation rate - %)	-0,004	-0,163	0,8709	0,9727	0,253	3,953	0,0002	0,7932
4p	Students per 1000 inhabitants	-0,025	-0,502	0,6168	0,9728	0,201	4,430	0,0000	0,8026
4q	Foreign languages learnt per pupil	-1,386	-1,644	0,1030	0,9735	10,671	3,339	0,0013	0,7817
4r	Public expenditures on education as a percentage of GDP	0,461	1,197	0,2337	0,9731	-3,294	-4,085	0,0001	0,7958
4s	Participation in education	-0,029	-0,656	0,5131	0,9728	-0,957	-3,184	0,0021	0,7789
4t	18-years-olds in education	0,050	1,628	0,1064	0,9735	0,191	5,631	0,0000	0,8263
4u	Mathematics, science &technology graduates per 1000 of population aged 20 -29	-0,036	-0,459	0,6471	0,9727	0,416	2,682	0,0089	0,7703
4w	Internet access per 100 inhabitants	0,022	1,202	0,2319	0,9731	-0,331	-4,126	0,0001	0,7966
4x	Number of mobile phone subscriptions per 100 inhabitants	-0,009	-0,455	0,6502	0,9727	0,049	7,353	0,0000	0,8578

Source: own calculations based on Eurostat data.

It is worth emphasizing that R&D budget expenditures considerably affect on the employment rate only in the EU-15, while R&D expenditures financed by industry in both groups of the EU`s countries exert an inverse result – in the EU-15 they determine a fall, while in the new member countries – a rise of the employment rate. It is probably connected with more advanced technological solutions introduced in more developed countries of the EU, which causes redundancies caused by the increase in productivity – human labour is replaced by machines more often than in new member countries where outdated stock of machines is exchanged.

The countries of Central and East Europe, being members of the EU, are making up for the social distance in relation to the EU-15, they intensify their participation in the educational system (of school and non-school education). Profitable transformations in this sphere are reflected in the improvement of labour market condition expressed by the employment rate affected by characteristics describing the educational system – most variables from the "Education and trainings" sphere have a positive (and statistically significant) effect on the level of the employment rate. By comparison, in the EU-15 an essential impact on the employment rate was observed only in case of the variable expressing the period of remaining in the educational system (the number of years spent on learning). Access to mobile telephony turned out a profitable determinant of the employment rate (only for new member countries). There is a negative connection between the employment rate and public expenditures on education (similarly in the case of connection with investments), participation in education and Internet access. Causes of the negative connection between the employment rate and participation in education can be detected in the inappropriate educational system of students whose competence and qualifications are useful and used in a small degree in economy[7]. The negative impact of network access on the researched macroeconomic category may result from low and often decreasing values of this characteristic.

[7] Participation in education is understood as the share of students in public high schools in the total number of students expressed as a percentage. It is higher than 90% in new EU`s members, in Belgium it amounted to 43% in 2007, in Holland 24%. Compare: *Eurostat.*

4. Conclusion

Summing up the considerations of correlations occurring between characteristics describing knowledge-based economy (investments and the employment rate) in the European Union's states in the period 2000-2007 the following conclusions can be drawn:

- Development of knowledge-based economies affects significantly economic development of the European Union's states;
- This impact is especially strong in case of new member countries characterized by a lower level of socio-economic development in comparison to the EU-15;
- In the considered 24 European Union's states a positive impact can be noticed on macroeconomic categories of most characteristics describing educational system in these countries as well as expenditures on research and development activity (that is the share of total R&D expenditures in GDP, including budget expenditures);
- In the group of new EU`s members the analysed macroeconomic categories are positively affected by the majority of variables characterizing the educational system, patent activity as well as access to mobile phones and human resources in science and technology;
- As it was revealed by the analysis in this group of countries a few characteristic describing knowledge-based economy affect negatively macroeconomic categories, mainly the employment rate. It concerns especially expenditures on education, participation in education and broadband access. The negative impact of public expenditures on education on the macroeconomic dimensions in the new member states can be explained by their low level in absolute terms, as well as intending for spheres, development of which does not contribute to the increasing of economy innovation and does not cause the increase of the examined macro dimensions. The negative correlation between participation in education and the employment rate may result from an inappropriate system of students' education whose qualification do not suit the needs of economy. Whereas the negative impact of the Internet access on the analysed macroeconomic category may be a result of low and decreasing values of this indicator in the considered countries;
- The cause of such unprofitable correlations of this type in the group of the new EU member countries is in the lack of coherent innovation strategy, based on strengthening of "knowledge triangle" that should consist of

scientific research, education and innovations as well in insufficient R&D expenditures financed from the budget and from enterprises' resources[8].

The conducted analysis proves that most knowledge-based economy characteristics show a positive impact on the selected macroeconomic categories in the European Union's states. Then it can be stated that the findings of the analysis confirm enforcing of Lisbon Strategy assumptions according to which the process of education and innovation of economies based on broadly understood scientific research, especially in modern fields of science, are main factors of development and ensure permanent economic growth.

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Streszczenie

OCENA ZALEŻNOŚCI MIĘDZY CHARAKTERYSTYKAMI GOSPODARKI OPARTEJ NA WIEDZY A WYBRANYMI KATEGORIAMI MAKROEKONOMICZNYMI W KRAJACH UNII EUROPEJSKIEJ

Kierunki przemian w gospodarce światowej, zachodzących w ostatnich latach, wskazują na przechodzenie od gospodarki ery przemysłowej do gospodarki wiedzochłonnej, opartej na potencjale technologicznym i innowacyjnym. Czynnikami decydującymi o rozwoju gospodarczym stają się działalność badawczo - rozwojowa (B+R), działalność innowacyjna i tzw. kapitał ludzki. W konsekwencji głównym przedmiotem badań prowadzonych w krajach wysoko rozwiniętych jest poszukiwanie źródeł innowacyjności i metod budowania potencjału innowacyjnego, które stają się podstawą kreowania gospodarki opartej na wiedzy. Istotny wpływ wiedzy i innowacji na rozwój gospodarczy potwierdza również współczesna ekonomia, która dowodzi, że postęp techniczny oraz akumulacja wiedzy naukowo-technicznej i kapitału ludzkiego oddziałują na rozwój współczesnych gospodarek w większym stopniu niż tradycyjne czynniki produkcji.

Celem artykułu jest analiza wpływu zmiennych opisujących gospodarkę opartą na wiedzy na podstawowe kategorie makroekonomiczne – udział całkowitych inwestycji w PKB i stopę zatrudnienia - w krajach Unii Europejskiej (z podziałem na kraje UE-15 i nowe kraje członkowskie UE) w latach 2000-2007, przeprowadzona w oparciu o modele panelowe.