

DYNAMICS OF CHANGES IN ROMANIA KNOWLEDGE ECONOMY

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Abstract: *By joining the European Union, the new member states have benefited from more opportunities for interaction and knowledge transfer, which boosted the transition to the knowledge economy. This paper deals with three areas that are the drivers of KE, education, research-development-innovation and information for a selection of European countries, which are the new EU member states (NMS). It focuses on identifying the current state of growth performance in Romanian economy in relation to some of the relevant KE indicators, the main tendencies manifested in the last years and their contribution to the KE development within the EU's developing countries group. The findings of the research reveal that the Romanian economy performance in KE terms has registered a positive dynamism, but this country is not on the efficiency frontier yet, being closer rather to the middle level of development from the new EU member states.*

Keywords: *Data envelopment Analysis, Knowledge economy, Economic growth, Economic performance*

JEL classification: *I25; O11*

1. Introduction

Over the last years, the economic growth in Europe has been reduced with some noticeable differences of competitiveness compared to other regions of the world (Nijkamp and Siedschlag, 2011). In order to surpass this situation, the Lisbon Strategy (2000) recommended to the EU countries to create a stimulating framework based on knowledge and innovation aimed at improvement of competitiveness and economic growth, and at enabling the transition to knowledge-based economies. Countries that later joined the EU including Romania have adopted the European economic-social model of development and strived to approach the features of advanced countries, in which the Knowledge Economy (KE) is already a reality. This paper has as objective to analyze the progress made by Romania to develop an economy based on knowledge. In a Knowledge Economy the economic growth is closely linked to knowledge production and its utilisation with higher efficiency in the entire society (Karagiannis, 2007).

The study aims to answer some questions, such as: What is the present stage of KE within the countries that joined the EU later? What are the trends related to the specific areas of KE in these countries and in Romania?

For answering these questions, the research is carried out in the following stages: selection of main specific indicators for domains related to the KE in EU's NMS (importance, availability of data, statistic significance); assessment of KE pillars performance in each country of the group and on the assembly; comparative analysis of the efficiency scores for KE pillars in Romania in comparison to countries which are on the efficiency frontier and to the average score of the overall selected countries.

The research method used is Data Envelopment Analysis (DEA). For selected countries, the efficiency analysis models depending on education, research-development and ICT (information and communication technologies) have been estimated. These components are considered the key factors to boost the economic growth in KE terms. The efficiency frontier identified allows appreciating the relative performance gaps between each country and the group leaders, and formulating some future action directions.

For Romania, the results indicate a greater contribution to growth of the KE drivers compared to the moment of accession. But the relative performance of each KE component is low.

Reducing development gaps between the country and the other EU members, and accelerating the transition to knowledge economy will only be possible by implementing some coherent policies to stimulate especially innovation and investments in human capital.

2. Literature review

After the middle of the twentieth century the growth theories considered that long-run economic growth could not be explained only by the capital accumulation. Arrow (1962) introduced the idea that through learning, labour force can accumulate experience, increase productivity and accelerate the economic growth. The studies of Romer (1986) and Lucas (1988) also pointed out the prominent role of human capital, and that a stable growth rate can result by accumulation of knowledge. More recently literature has analyzed the knowledge based economy pattern. In this economy, knowledge is regarded as main element of development process, ensuring high economic growth and opportunities for social progress (Chen and Dahlman, 2005).

The studies performed by the World Bank reveal that a strong relationship exists between knowledge accumulation and economic development. The higher the knowledge stock is (measured by Knowledge Economy Index), the greater the level of the countries' economic development is (World Bank, 2012a).

The Lisbon Strategy stated that the Knowledge-based Economy should be the priority direction for progress and economic development in Europe. Stimulating the knowledge creation and utilization in every domain aimed for Europe to improve the economic, social and environmental performance in the next decade, in order to transform in the most competitive region in the world with a sustainable economic development.

Changing an economy into a Knowledge-based economy requires some actions, such as radical transformation of Information and Communication Technologies system, enhancing the research and development sector, increasing of the competitiveness, consumption and incomes, orientation to quality (Coates and Warwick, 1999).

Recent studies concerning the world's regions or countries, analyzed the Knowledge-based Economy according to elements such as R&D effort, quality of human resources, innovation capacity, IT diffusion, access to finance and information society (Karagianis, 2007), sustained investments in education, innovation, information and communication technologies, and a conducive economic and institutional environment ((Chen and Dahlman, 2005), human capital, innovation ability, information access (Nijkamp and Siedschlag, 2011), industry R&D, venture capital, workforce education, fast growth firms (Watkins, 2008), knowledge workers

(ICT sensitivity, educational level, creative class and communicative skills), R&D and innovativeness (Westeren, 2012).

To create an unique framework and ease the evaluation of a country's progress towards the Knowledge Economy, the World Bank has developed the Knowledge Assessment Methodology (Chen and Dahlman, 2005; World Bank, 2012a). According to it, the countries' readiness for the Knowledge Economy is appreciated based on numerous indicators which are synthesised by four pillars: economic and institutional regime, education and skills of population, information infrastructure and innovation system.

Also, in Romanian specific literature the interest for Knowledge Economy is perceived. The studies concern various theoretical aspects related to KE and its perception by companies (Ceptureanu et al., 2012), assessment of ICT indicators contribution to KE using World Bank methodology (Goschin and Constantin, 2007), constrains in innovation implementation (Brătianu and Vasilache, 2009), relation with sustainable development etc. This present study intends to evaluate the advances of Romanian economy towards KE after joining the EU, in a comparative manner against the other developing countries of the European Union using a nonparametric method. The advantage of this approach is that one can have a synthesis picture of how effective the country uses its internal resources to generate knowledge and economic value.

3. Methodology

In this study, the performance and trends assessment of the KE drivers is performed using Data Envelopment Analysis (DEA) approach. DEA is a nonparametric method by which a linear programming model is built based on some empirical outputs and inputs for a number of decisional units.

Resolving the model leads to identification of an efficiency frontier on which the most performing states are positioned (efficiency score is 1), all the other countries that have efficiency score less than 1 being considered inefficient. The performance scores obtained allow both ranking of the decisional units (countries) according to their relative individual performance, which depends on the conditions and variables specified, as well as pointing out the ways to increase efficiency.

In this paper, the CRS (constant returns to scale) output oriented model proposed by Charnes, Cooper, and Rhodes (1978) and the ratio form of data as suggested by Coelli et al. (2005) were used. This model considers k decisional units, each of them with n inputs and m outputs.

The efficiency for the decisional unit k is as follows:

$$E_k = \frac{\sum_{j=1}^m v_j y_{kj}}{\sum_{i=1}^n u_i x_{ki}} \quad \text{s.t.} \quad \frac{\sum_{j=1}^m v_j y_{kj}}{\sum_{i=1}^n u_i x_{ki}} \leq 1 \quad ; \quad \forall u_i, v_i \geq 0$$

in which: u_i represent weights of inputs; v_j represent weights of outputs variables.

Data are for period 2007-2011 and aim the main aspects of production, use and dissemination of knowledge in the new EU member states: Czech Republic (CZ), Estonia (EE), Cyprus (CY), Latvia (LV), Lithuania (LT), Hungary (HU), Malta (MT), Poland (PL), Slovenia (SL), Slovakia (SK), Bulgaria (BG) and Romania (RO).

In order to analyze their possible economic growth driven by knowledge capacity, indicators were used from domains known as key sources for boosting development, namely human capacity, innovation ability and information access (Nijkamp and Siedschlag, 2011; World Bank, 2012a). The representative indicators have been selected according to the results of some previous researches concerning the determinant factors of economies based on knowledge and provided by the EU statistics: "Education and training", "Science, technology and innovation" and "Information society". The "Gross Domestic Product at market prices per capita" (GDP) was used to appreciate the economic performance because its level expresses the returns from investments in knowledge factors made by a country.

4. Results and discussions

The assessment of challenges in Romania Knowledge Economy was performed with Data Envelopment Analysis techniques considering the three pillars that can stimulate growth and development. To identify the country's progresses to an economy based on knowledge, comparisons with the other new EU member states have been made for two time periods, namely 2007 (when Romania joined the EU) and 2010 (most recent year with complete information in databases).

A). The education system has a major contribution to the increase of the stock of global knowledge by which a country can more rapidly advance towards KE. The indicators used to evaluate the impact of education on KE were selected according to their potential to boost the innovation process and knowledge transfer (Table 1).

Table 1: Indicators of knowledge economy on education

Country	GDP per inhabitant		Participation rates in education, %		GMST per 1000		Public expenditure on education	
	2007	2010	2007	2010	2007	2010	2007	2009
BG	10000	10700	52.4	53.7	8.4	11.4	9.77	11.26
CZ	20700	19500	62.1	62.7	12.0	16.5	9.88	9.76
EE	17500	15500	62.1	62.1	13.3	11.3	13.88	13.46
CY	23600	23600	41.2	47.6	4.2	5.1	16.81	17.26
LV	14300	13200	62.5	61.1	9.2	10.7	13.98	12.77
LT	15500	14900	68.7	69.3	18.1	18.7	13.39	12.88
HU	15400	15900	63.7	65.6	6.4	8.3	10.44	9.96
MT	19500	21000	44.5	47.2	7.1	8.0	14.79	12.56
PL	13600	15300	70.3	70.8	13.9	15.8	11.65	11.45
RO	10400	11400	53.6	56.1	11.9	15.6	11.11	10.31
SL	22100	20500	70.1	71.0	9.8	14.8	12.15	11.57
SK	16900	17900	56.3	58.1	11.9	18.3	10.59	9.85

Source: Eurostat database

Indicators from Table 1 contain some empirical observations of outputs and inputs for the envelopment problem solved by DEA technique. The output is represented

by the indicator „GDP at market price, PPS per inhabitant” and inputs are the variables: „Participation rates in education (students aged 15-24 years as % of corresponding age population)”, „Graduates in mathematics, science and technology per 1000 of population aged 20-29 years” (GMST) and „Total public expenditure on education as % of total public expenditure, for all levels of education combined”. Although there are other important indicators in knowledge creation and dissemination (i.e. language learning), the missing data for some countries has led to restriction of the number of indicators used in analysis.

The model was solved in CRS version and output-oriented version and the results obtained are in Table 2.

Table 2: DEA results. Economic performance of KE on education

Country	2007		Country	2010	
	Performance score	Position		Performance score	Position
CZ	1.000	ef.	CZ	1.000	ef.
CY	1.000	ef.	CY	1.000	ef.
SL	1.000	ef.	MT	1.000	ef.
HU	0.881	inef.	SV	0.947	inef.
MT	0.876	inef.	SK	0.940	inef.
SK	0.831	inef.	HU	0.921	inef.
EE	0.713	inef.	PL	0.703	inef.
LT	0.613	inef.	EE	0.664	inef.
LV	0.601	inef.	LT	0.619	inef.
PL	0.569	inef.	LV	0.596	inef.
BG	0.554	inef.	RO	0.589	inef.
RO	0.511	inef.	BG	0.531	inef.
Mean	0.762	-	Mean	0.792	-

Source: DEAP soft

Czech Republic, Cyprus and Malta are countries that took advantage of education system in growth. Romania presented a positive trend of its relative efficiency score (4%) but this is still reduced in comparison to the scores of group leaders and even to the average level of the indicator, being classified as inefficient. The study of the indicators (Table 1) to determine the performance of the education system highlighted that there are not major differences of indicators in Romania against the countries on the efficiency frontier. In Romania (2010), the number of persons enrolled in secondary and tertiary education (15-24 years) is higher with 18% than of Cyprus and Malta. Graduates from the mathematics, science and technology fields are 3 times numerous than in Cyprus and 2 times more than of Malta. Also, the levels of these indicators are closely to those of Czech Republic. However, the Romanian education system has 41% lower efficiency than that of the other countries, meaning that its labour force did not sufficiently contribute to value creation within the economy.

One of the causes for which the knowledge acquired in schools did not have the expected effects in Romania's economic growth is unbalanced situation between knowledge and labour market demands. In Romania in 2009, the share of registered unemployed people under 29 years in the total unemployed persons was 24.2%

(N.I.S., p.114, 2010). Another cause for lower contribution of knowledge acquired by young people to the GDP formation is the phenomenon of their emigration to other countries. Thereby at the end of 2009, of the total persons who settled their permanent residence abroad, about 25.3% were under 25 years, and 52.3% of emigrants were 26-40 years (N.I.S., p. 79, 2010).

B). For determining the contribution of R&D factors to a better preparation for transitioning to Knowledge Economy for the EU new member states including Romania, the GDP (v. Table 2) and the indicators presented in Table 3 have been considered.

In the second DEA problem, the relevant inputs for identifying the technical and economic development potential of business environment are: „Business enterprise R&D expenditure”, „Human resources in science and technology” (25-64 years, % of active population) and “Enterprises with innovation activity” (product, process, ongoing or abandoned, organizational and marketing innovation), and output variable is GDP per inhabitant.

Table 3: Indicators of Knowledge Economy on research-development

Country	Business enterprise R&D expenditure, % of GDP		Human Resources in Science and Technology, %		Enterprises with innovation activity %	
	2007	2010	2007	2010	2008	2010
BG	0.14	0.3	30.8	31.6	0.3077	0.2711
CZ	0.92	0.96	36.0	37.8	0.56	0.5169
EE	0.51	0.82	44.4	45.0	0.5638	0.5684
CY	0.10	0.09	42.5	43.9	0.5611	0.4619
LV	0.19	0.22	37.2	37.8	0.2429	0.2986
LT	0.23	0.23	40.6	42.7	0.3028	0.3446
HU	0.49	0.7	31.7	33.0	0.2894	0.3106
MT	0.38	0.42	31.9	31.9	0.3741	0.4154
PL	0.17	0.2	32.5	36.3	0.2794	0.2814
RO	0.22	0.18	23.0	24.4	0.3331	0.3082
SL	0.87	1.42	38.9	40.8	0.5028	0.4940
SK	0.18	0.27	31.8	33.5	0.3605	0.3559

Source: Eurostat database

The comparison between countries in terms of their relative performance of their R&D system towards KE identified for 2010 Cyprus, Malta and Poland on the efficiency frontier (Table 4). All the other countries had in comparison to them a lower efficiency of the research and innovation process.

Romania had an relative efficiency score with 21.5% lower than the group leaders, situation which can be explained by the existence of a more reduce capacity to produce and apply innovative knowledge, therefore this direction seems to be a reserve to increase the performance. In the world ranking on economies competitiveness made by the World Economic Forum, Romania also has a low score for the innovative capacity (3.2 on 1 to 7 scale) (Schwab, 2012).

Table 4: DEA results. Economic performance of KE on research-development

Country	2007		Country	2010	
	Perform. score	Position		Perform. score	Position
CY	1.000	ef.	CY	1.000	ef.
MT	1.000	ef.	MT	1.000	ef.
SK	1.000	ef.	PL	1.000	ef.
LV	0.951	inef.	HU	0.974	inef.
CZ	0.941	inef.	SK	0.967	inef.
HU	0.817	inef.	SL	0.826	inef.
RO	0.757	inef.	LV	0.810	inef.
PL	0.750	inef.	LT	0.808	inef.
LV	0.699	inef.	RO	0.785	inef.
LT	0.686	inef.	CZ	0.784	inef.
EE	0.647	inef.	BG	0.740	inef.
BG	0.581	inef.	EE	0,541	inef.
Mean	0.819	-	Mean	0.853	-

Source: DEAP soft

C). The analysis of the impact of information and communication technologies on economic growth used some indicators related to the information infrastructure utilized in enterprises activity, and the extent of its financing (Table 5).

Table 5: Indicators of Knowledge Economy on ICT, EU's NMS, 2007-2010

Country	Enterprises having Internet access, %		Enterprises using computers, %		Information Technology expenditure, % of GDP	
	2007	2010	2007	2010	2007	2010
BG	75	85	85	90	1,0	1,7
CZ	95	95	97	96	2,2	2,2
EE	94	96	95	97	1,4	1,4
CY	88	88	95	92	-	-
LV	86	91	95	95	1,1	1,1
LT	89	96	91	97	1,1	1,2
HU	86	90	91	91	1,7	1,8
MT	95	94	97	96	-	-
PL	92	96	95	97	1,7	1,7
RO	67	79	82	82	1,1	1,2
SL	96	97	98	98	1,6	2,0
SK	98	98	99	98	2,0	1,9

Source: Eurostat database

The hierarchy of the EU's developing countries according to the efficiency of information indicators provided by DEA is presented in Table 6.

Table 6: DEA results. Economic performance of KE on ICT

Country	2007		Country	2010	
	Perform. score	Position		Perform. score	Position
LT	1.000	ef.	LT	1.000	ef.
SL	1.000	ef.	SL	1.000	ef.
CZ	0.947	inef.	CZ	0.971	inef.
LV	0.925	inef.	LV	0.966	inef.
EE	0.899	inef.	EE	0.952	inef.
HU	0.778	inef.	SK	0.904	inef.
SK	0.757	inef.	HU	0.853	inef.
BG	0.714	inef.	PL	0.833	inef.
RO	0.684	inef.	RO	0.830	inef.
PO	0.642	inef.	BG	0.608	inef.
Mean	0.835	-	Mean	0.892	-

Source: DEAP soft

The assessment of developing countries based on the efficiency of their ICT sector recorded in 2010, ranked Romania on the second last place in the group of 12 states, with a relative score of 0.83. In the hierarchy made by the World Economic Forum based on the Networked Readiness Index 2012, it was ranked 67th out of 142 countries with a score of 3.9 (1 to 7 scale); among the EU countries it ranked ahead only of Bulgaria (Dutta and Bilbao-Osorio, 2012).

Although, the ICT has increased the contribution to economic growth with 14.6% compared to 2007, Romania, with an efficiency score lower with 17% than Lithuania and Slovenia, is still below the average level of efficiency in the group of EU's NMS.

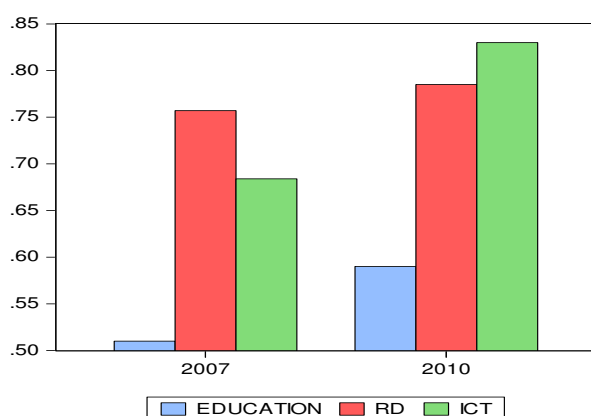


Figure 1: Evolution of relative performances of KE drivers in Romania

According to Figure 1, in Romania there was an improvement of the performance score of the education system with about 8%, but it is much lower than the average level of new EU member states. In this sector, some adequate strategies for increasing the share of enrolments in education, stimulating professional training for high-tech activities and better financing are required.

The efficiency trend of resources used for knowledge creation and utilization by R&D sector was also positive, but its relative increase was higher only with 3% in comparison with the accession year. In order to reduce the performance gap against other countries, the rhythm of innovation should be intensified. This action implies more investments in research-development activities, increasing the share of labour force that works in this area and extending application of research results in production. There are some consistent results from investments in information infrastructure, which contributed to the increase of performance with 14.6%. Extending the ICT technologies within enterprises allowed knowledge dissemination and utilisation on a large scale and a higher contribution to value creation in the national economy. For the future, development of the information society will remain an important direction to stimulate the economy based on knowledge.

Results of the analysis undertaken are consistent with recommendations made by the World Bank. In Romania, in order to accelerate the participation of knowledge disadvantaged communities in the Knowledge-based Economy, it is necessary to develop areas such as education, innovation support for enterprises, businesses and public communications with the Government, the financial self-services, e-commerce (World Bank, 2012b).

5. Conclusions

Among the countries that later joined the EU, there are some disparities in utilisation of the resources that are specific to the Knowledge Economy. The Data Envelopment Analysis technique has been applied to determine the efficiency of educational factors, elements of R&D, and ICT factors in correlation to the GDP, and the relative performance scores for each KE pillars were obtained. The efficiency frontier separates the analyzed countries in two groups: efficient countries – those with maximum performance scores and inefficient countries – other countries, which have lower scores than efficient ones. For all of the pillars Romania belongs to the group of inefficient countries.

Due to the differences of economic growth between Romania and the other new EU member states, it ranked in a modest position, with important implications for the quality of population's life. However, compared to the moment of accession, Romania has registered some progresses in KE terms.

The area where less progress has been made compared to other countries is education. Although at the national level, educational factors contributing to the GDP increased significantly, in relative terms their performance remains quite low and somehow, justified. The structural changes of economy caused by the accession in the EU led to emergence of some uncontrollable phenomena (migration of population being only one of them), the economic effects of investments in people not being present in totality in the country. Another cause is insufficient funding of the sector infrastructure.

Increasing the competitiveness and dynamism of the Romanian economy requires effective policies to be designed. They should address the measures of increasing the internal resource performance, especially in areas that can generate knowledge and innovation, and should continue to benefit from the ICT growth potential.

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