THE IMPACT OF THE KNOWLEDGE ECONOMY INDICATORS ON REGIONAL ECONOMIC GROWTH: EVIDENCE FROM KAZAKHSTAN

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ABSTRACT

This paper presents an evaluation of the efficient role of knowledge based components, including effectiveness of government program, knowledge creation, information and communication technologies (ICT) and R&D and innovation factors in motivating economic growth of developing emerging economies, particularly in the Republic of Kazakhstan. For this purpose, a panel regression model is used to analyze the data collected from the Statistics Committee of the Ministry of National Economy during the years 2007–2017. The results extracted from an econometric model selected such factors as initial R&D expenses, number of organizations (enterprises) engaged in R&D and percentage of obtained patents and articles with impact factor per researcher get the impact to the economic growth of country. Furthermore, the study investigates efficiency of selected knowledge-intensive factors using Data Envelopment Analysis (DEA) based on CCR model, which showed that R&D expenses among of the regions of Kazakhstan is not equable and efficiency of other indicators like science and knowledge workers, knowledge creation and use of information and communication technologies (ICT) is low.

KEYWORDS: *Data Envelopment Analysis (DEA), economic growth, knowledge-based economy.*

1. INTRODUCTION

The topic of the knowledge economy has got the great importance in recent years in policy discussions on economic growth, globalization and economic restructuring. In fact, governments in many developed and developing countries are engaged in the search for developing policies that promote essential elements of a knowledge economy manifested in: education and training; information and communication technologies; research and development, and innovation; and conducive governance and regulatory regimes that nurture such elements. In the framework of improvement the sustainable development of Kazakhstan, on the basis of diversification and modernization of the economy, clear goals and tasks are set for moving from a raw material economy to a knowledge-based economy through the use of revenues from the oil, gas and mining industries (Zhuparova et al., 2018). In this context, it is the aim of this research to explore and identify key factors for knowledge economy development in the Republic of Kazakhstan to assist in achieving a sustainable economic development: «What is the current readiness of Kazakhstan's knowledge economy key drivers in terms of the quality and effectiveness of government institutions and economic incentives, knowledge creation, information and communication technologies (ICT) and R&D and innovation». In this way, despite the fact that regional knowledge clusters form essential "building blocks" for the knowledge economy and knowledge-based society at national and global levels, very little attention has been paid to the modeling of knowledge generation at a regional level.

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Kazakhstan's key innovation policy started with 2010-2014 National Program, which is connected with forced industrial and innovative development of the country. It aimed to support a stable economic growth through the diversification and improvement of Kazakhstan's competitive ability.
At present, the government implements the State Program on industrial development of Kazakhstan for years 2015 - 2019, which aims to promote diversification and competitiveness of the manufacturing industry.

2. LITERATURE REVIEW

Heshmati and Shiu (2006) also investigated the ICT growth in 30 provinces of China during 1993 – 2003 using panel data analysis. The findings show that foreign direct investment (FDI) and ICT investment have positive and significant effect on total productivity growth. One percent increase in ICT investing increases total productivity for 0.46 % while FDI increases total productivity for 0.98%. Based upon their findings, ICT has a positive and significant effect on the production growth and ICT, but it is small and like other developing countries, the impact of non-ICT capital on growth is more profound which stems from the lack of some complementary factors like human capital and proper infrastructure.
Sagiyeva et al. (2018) indicate finding answers about defining necessary resources for the creation and functioning of a knowledge-based economy in Kazakhstan and measuring intellectual potential and intellectual in the context of the transition to a knowledge-based economy. Recent studies propose that IC needs to be explored together with KM activities and processes to better understand how intangibles drive innovation performance (Kianto et al., 2014; Wang et al., 2016; Ling, 2013). Cabrilo and Dahms (2018) consider knowledge based resources (such as IC) to be static assets that have to be dynamically managed to be transformed into value.
Berghäll (2012) examined the premise that catch-up with the global technology frontier calls for a shift from physical investment to innovation in a stochastic frontier (SF) model applied to an unbalanced panel of Finnish firms in a dynamic and innovative leading R&D industry, that is, Finnish ICT equipment manufacturing over a period of rapid technological progress from 1990 to 2003. In our case, we have selected such factors as innovation and technology level, R&D investments, science and knowledge workers, knowledge creation, use of information and communication technologies (ICT) in order to identify key factors for knowledge economy development.

3. METHODOLOGY

At the first step of the empirical analyses we constructed regional-level panel data for the 2007–2017 period based on the databases maintained by the Statistics Committee of the Ministry of National Economy. Our data covers 15 regions of the Republic of Kazakhstan, besides our combined database provides regional level information as follows:

A. Innovation and technology level:

Innovative activity of organisations (the ratio of organisations implementing technological, organisational and marketing innovations to the total number of organisations) (1);
Volume of innovative products (goods, services) (2);

B. R&D investments:

Internal expenditures on research and development (R&D) (3);
Expenses for product and process innovations in industry (4);
Information technology expenses (5);

C. Science and knowledge workers:

Number of organizations (enterprises) engaged in research and development (6);
Number of employees engaged in research and development (7);

The share of workers employed in high-tech industries (8);

D. Knowledge creation:

Percentage of obtained patents and articles with impact factor per researcher (9);
Share of patents in total research (10);

E. Use of information and communication technologies (ICT):

Number of information technology specialists (11);
Number of organizations using Internet (12);
Proportion of organisations using the Internet (13);
Share of enterprises using new technologies in the total number of enterprises (14).

These 14 variables and indicators are model inputs characterising the level of development of the knowledge economy in the region. We chose the proportion of regions in the gross regional product (GRP) as an output or resultant variable, since it is the most objective indicator of economic development.

Independent variables (2), (3), (4), (5), (6), (7), (11), (12) are absolute, in order to make them independent of the dependent variable and diversity of the data, we decided to normalise these figures according to the function scale() in R, which standardizes a given column of a matrix or data table so that its arithmetic average is zero and the standard deviation is one.

We run the following ordinary linear regression model in order to achieve the objectives of the paper. At the result of applying OLS regression it was selected features with any significance level and created the following reduced model and selection between these two models was applied by using Akaike test.

GII report has already presented innovation efficiency of countries simply by calculating the ratio of the average of innovation outputs to the average of innovation inputs (Cornell et al., 2015). Although uncertainty in the DEA approach has been the subject of considerable research effort (Bruni et al., 2013; Iazzolino et al., 2013).

At the second step of our research we applied DEA model in order to estimate the efficiency of state program to development of knowledge-intensive economy according to the created linear model. Data envelopment analysis (DEA) is widely-used technique for evaluation of decision making units' relative efficiency with multiple inputs and outputs characteristics. It was supposed that the set of decision making units (DMUs) included n elements. The DMUs are evaluated by m inputs and r outputs with input and output values x_{ij}, i = 1, 2,…, m, j = 1, 2,…, n and y_{kj}, k = 1, 2,…, r, j = 1, 2,…, n, respectively. The efficiency of the q-th DMU can be calculated as the weighted sum of outputs divided by the weighted sum of outputs with weights that reflect the importance of single inputs vi, i = 1, 2,…, m, and outputs u_k, k = 1, 2,…, r as follows: u_{ky}

$$\varphi_q = \frac{\sum_{k=1}^{r} u_{ky} w_{kq}}{\sum_{i=1}^{m} v_i x_{iq}}$$

Charnes et al. (1978) gave formulation of standard CCR input oriented DEA model, which evaluates in maximization of efficiency score of the DMU_q subject to constraints that efficiency scores of all other DMUs are lower or equal than 1. The linearized form of this model is as follows:

Maximize

$$\varphi_q = \sum_{k=1}^{r} u_k w_{kq}$$

Subject to

$$\sum_{i=1}^{m} v_i x_{iq} = 1,$$

$$\sum_{k=1}^{r} u_k w_{kj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0, \qquad j=1, 2, \dots, n,$$

$$u_k, v_i \geq \varepsilon, \qquad k = 1, 2, \dots, r, i=1,2,\dots, m.$$

If the optimal value of the model (1) φ_q measure up 1 then the DMU_q is CCR efficient and it is lying on the CCR efficient frontier, otherwise the unit is not CCR efficient.

4. FINDINGS AND DISCUSSIONS

To estimate the model, we use panel data analysis and to specify the model type —independently pooled panels, fixed effects model, random effects model — we use two tests of F and t-statistics. Panel data, by blending the inter-individual differences and intra-individual dynamics, have several advantages over cross-sectional or time-series data. We study the effects of the independent variables (described in the previous section) on regional percentage of GRP with the following model, which was implemented in R:

Table 1. OLS regressions of the model

Variable name	Model 1 (t value)	Model 1 (Pr(>|t|))	Model 2 (t value)	Model 2 (Pr(>|t|))
Intercept	-0.331	0.7408	-0.330	0.742
Initial R&D expenses *(X1)*	4.385	2.21e-05***	5.033	1.35e-06***
Innovative activity of organizations *(X2)*	-1.726	0.0865.	-2.349	0.0201*
Expenses for product and process innovations in industry *(X3)*	2.139	0.0341*	2.029	0.0442*
Volume of innovative products (goods, services) *(X4)*	-0.571	0.5686		
Number of organizations (enterprises) engaged in R&D *(X5)*	5.209	6.34e-07***	5.819	3.39e-08***
Number of employees engaged in R&D *(X6)*	-2.019	0.0453*	-1.908	0.0583.
Number of information technology specialists *(X7)*	0.367	0.7143		
Information technology expenses *(X8)*	2.487	0.014*	3.11	0.00223**
Number of organizations using Internet *(X9)*	1.303	0.1946		
The share of workers employed in high-tech industries *(X10)*	1.273	0.205		
Percentage of obtained patents and articles with impact factor per researcher *(X11)*	-3.422	0.00081***	-3.464	0.00069***
Share of patents in total research *(X12)*	0.458	0.64744		
Proportion of organisations using the Internet *(X13)*	-2.213	0.02843*	-1.588	0.1144
Share of enterprises using new technologies in the total number of enterprises *(X14)*	2.536	0.01227*	2.692	0.0079**
Adjusted R^2	0.832		0.834	
p - value	2.2e-16		2.2e-16	
Akaike	188.455		182.013	

Note: Signif. codes: 0 '*' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1**

Table 1 presents the results of the linear regression (OLS) on the dependent variable "proportion of regions in the GRP". Consistent with the first regression model 1, percentage of obtained patents and articles with impact factor per researcher has a significantly positive influence on the indicator of economic development. Again, Number of organizations (enterprises) engaged in R&D also increases the indicator of economic development. As expected, there is a positive and highly significant effect from "Initial R&D expenses", which means that the level of financial investment does strongly influence the share of proportion of regions in the GRP. At the less significant level it is noticed such indicators as Expenses for product and process innovations in industry, Number of employees engaged in R&D, Information technology expenses, Proportion of organisations using the Internet, Share of enterprises using new technologies in the total number of enterprises.
In this way, it was applied reduced model 2 with factors, which showed some level of significance and get influence to the dependent variable according to table 1. It can be clearly seen, that such independent variables as Initial R&D expenses, Number of organizations (enterprises) engaged in R&D, Percentage of obtained patents and articles with impact factor per researcher got the highest significance level, Information technology expenses, Share of enterprises using new technologies in the total number of enterprises got less significant level, and Innovative activity of organizations, Expenses for product and process innovations in industry got the smallest significance to the dependent variable. At the result of comparing of efficiency of these 2 models, it was selected model 2 results for DEA applying because, Adjusted R^2 of the reduced model was higher than in the first one, besides Akaike test was selected the second model.

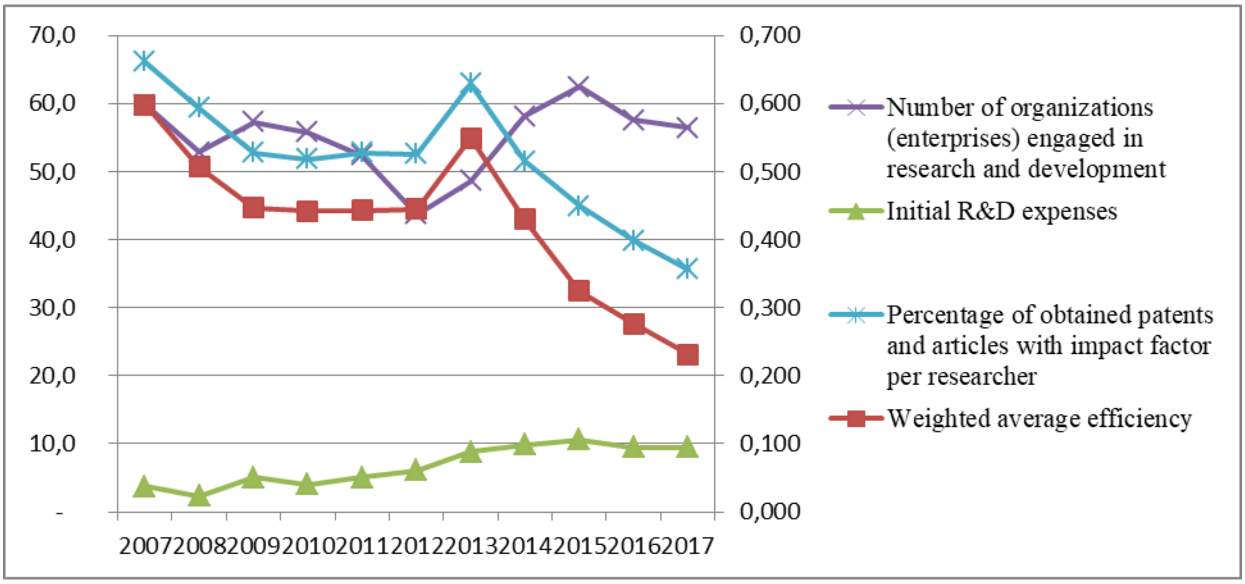

Figure 1. Tendency of changes of weighted average efficiency
Source: own compilation

So, during the applying of DEA it was used Initial R&D expenses, Number of organizations (enterprises) engaged in research and development, and Information Technology expenses, Percentage of obtained patents and articles with impact factor per researcher and Share of enterprises using new technologies in the total number of enterprises as input values and proportion of regions in the GRP was used as output value. According to the results of efficiency for each DMU (appendix 1) and data of the main selected indicators it is noticed that despite increasing value of Initial R&D expenses, efficiency of economic growth got worth, at the weighted average estimation knowledge creation has fell down (figure 1).

Table 2. Knowledge-based economy indicators performance

DMU	R&D investments	Science and knowledge workers	Knowledge creation	Use of information and communication technologies (ICT)	Overall efficiency
Aqmola region	0.778	0.238	0.143	0.057	0.778
Aqtobe region	0.776	0.244	0.098	0.07	0.802
Almaty region	1	0.378	0.335	0.189	1
Atyrau region	0	1	1	0.073	0
West Kazakhstan region	0.007	0.492	0.122	0.444	0.008
Zhambyl region	1	0.207	0.038	0.08	1
Karagandy region	0	0.251	0.083	0.428	0
Kostanay region	0.933	0.22	0.092	0.028	0.933
Kyzylorda region	0.833	0.307	0.045	0.036	0.83
Mangystau region	0	0.942	0.343	0.5	0.011
Pavlodar region	0.004	0.367	0.071	0.132	0
North Kazakhstan region	1	0.375	0.023	0.1	1
East Kazakhstan region	0	0.157	0.198	0.137	0.002
Astana	0	0.156	0.044	1	0
Almaty	0	0.152	0.255	0.545	0.073
Average	0.778	0.238	0.143	0.057	0,428571

Source: own compilation

Regarding the results of knowledge-based economy indicators performance (table 3) it could be clearly seen unbalanced distribution of R&D expenses and different level of efficiency of knowledge-based economy indicators accordingly.

5. CONCLUSIONS

The role of knowledge in the innovative socio-economic development has become absolutely critical: knowledge has become a major factor of economic growth and a key social value. A significant unit of the knowledge economy is comprised by the regional economic system. Kazakhstan regions were evaluated in terms of their knowledge economy development. As a result, the principle of regional development shall be constructed to improve the innovation efficiency over time and avoid degrading it due to changes in national or international political/economic situations. In this research, we presented DEA approach to evaluate the the current readiness of Kazakhstan's knowledge economy key drivers in terms of the quality and effectiveness of government institutions and economic incentives, knowledge creation, information and communication technologies (ICT) and R&D and innovation. As the proposed model offered a deep understanding of the interconnection between proportion of regions in the GRP and Initial R&D expenses, Number of organizations (enterprises) engaged in R&D, Percentage of obtained patents and articles with impact factor per researcher.

By implementing this new method, we found that investment in R&D among of the regions of Kazakhstan is not equable and it is not effective for development of other indicators like Science and knowledge workers, knowledge creation and Use of information and communication technologies (ICT).

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