Montenegrin Journal of Economics

Vol. 16, No. 3 (2020), 109-122

Measuring the Knowledge-Based Performance Efficiency in the Oil-Exported Countries

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ARTICLE INFO

Received January 07, 2020
Revised from February 16, 2020
Accepted March 20, 2020
Available online September 15, 2020

JEL classification:

O3, R1, C4

DOI: 10.14254/1800-5845/2020.16-3.9

Keywords:

Malmquist Productivity Index,
Data Envelopment Analysis (DEA),
knowledge-based performance,
oil-exporting countries.

ABSTRACT

The main challenge of natural resource-rich economies is to avoid the resource curse, poor economic growth, weak institutions and corruption through the development of state program, tended to the development of knowledge-based economy. This research evaluates the productivity of the gross regional product in the context of knowledge-based economy indicators taking into account industrial structure and specialization in regional economic. The focus is on the Republic of Kazakhstan as representative of the oil-exported countries. The feature selection analysis was implemented through a panel regression model and in the aim of evaluation of knowledge-based performance of state measures was used Malmquist Productivity Index in DEA. The data set of the research is obtained from the official statistical data of state structures during the period from 2007 to 2017 for the regions of Kazakhstan. The results indicate the need to develop differentiated approaches aimed at improving the efficiency of knowledge-based performance in the context of industry 4.0. The results can be used to adjust tactics and development strategies of state measures in knowledge-based performance. Through this paper we hope to give our contribution to the creation Smart Specialisation strategies in emerging economy countries as a way to increase efficiency in research and innovation investments by integrating policy areas, applying a broad definition of innovations and stimulating collaboration - between regions, sectors and levels.

INTRODUCTION

In recent years a knowledge economy has become a key issue in policy discussions on economic growth, globalization, and economic restructuring. The governments of developed and developing countries are engaged in a continuous search for the policies that promote essential elements manifested by the knowledge economy, namely education and training; information and communication technologies; research and development, and innovation, as well as conducive governance and regulatory regimes. In particular, it is quite important for oil-exporting countries, which strongly depend on revenues from oil prices. This means that these countries are faced with different economic consequences that low oil prices may have in their economy and political stability. What might happen could be the destabilization as a consequence of a lasting low oil price (Kitous et al., 2016). As oil-exporting countries witness the early signs of such a bearish market (Sleire, 2017), they struggle to fight back by investing their oil revenues on innovation and increasing return on innovation for long-term security (Sabah, 2013). We conducted an analysis four oil-exporting countries with Upper Medium Income and two countries with high income with the aim to benchmark the development of the knowledge-based economy of the Republic of Kazakhstan among other countries using European Commission Joint Research Center analysis. Kazakhstan is rich in natural resources including coal, oil, natural gas and uranium and has significant renewable potential from wind, solar, hydro-power and biomass (Kozhakhmetova et al., 2019).

In Figure 1 R&D expenditure as a share of GDP is lowest in Kazakhstan, it takes 3,3 % of world total crude oil production. Oppositely, Malaysia spends on R&D more (1,3%), than it produces crude oil (0,8%). Russia takes the second position of R&D spending (1,1%), representing 11,3% of total world crude oil production. The United Arab Emirates has approximately the same level of R&D expenditure despite half the share of crude oil production of Russia. Iran spends on R&D as triple times more as Kazakhstan despite a little inequality in crude oil production.

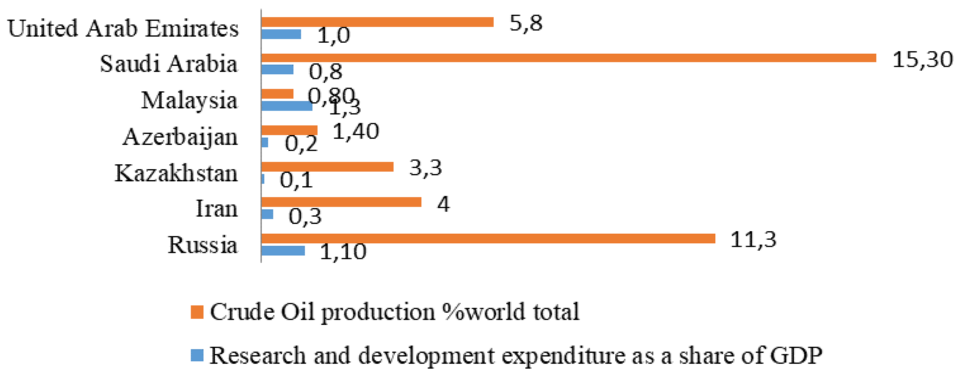

Figure 1. Crude Oil production %world total and R&D expenditure in GDP* (for the last available year)

Source: http://www.worldstopexports.com/worlds-top-oil-exports-country and www.knoema.com

As can be seen from Table 1, United Arab Emirates, Russian Federation, and Malaysia have a better position in Global innovation index with a ranking of 38, 35 and 46 accordingly. There are Iran and Saudi Arabia at the middle of selected oil-exported countries: Iran has a good position in business sophistication (45), knowledge and technology outputs (41) and human capital and research (45), Saudi Arabia has a good position in Human capital and research (24). So, Kazakhstan takes the 74th position at the Global innovation index, which is better than in Azerbaijan but worse than in other oil-exported countries. In the framework of improving the sustainable development of Kazakhstan, clear goals 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, this research aims to identify key factors and their status for knowledge economy development in the

Republic of Kazakhstan to assist in achieving sustainable economic development. In this way, taking into account regional management principle of policymakers for the knowledge economy and knowledge-based society at national and global levels, very little attention has been paid to the modeling a knowledge-based performance of state measures at a regional level. Kazakhstan, despite some potential for innovative development, is only at the initial stage of transition to an innovative economy, the formation of which the author is associated with an active role of the state on the creation of a favorable institutional regime and infrastructure (Kupeshova & Orynbassar, 2018). Kazakhstan's key innovation policy started with the 2010-2014 National Program of forced industrial and innovative development of the Republic of Kazakhstan. It aimed to guarantee a stable and well-balanced economic growth through diversification and improvement of Kazakhstan's competitive ability.

Table 1. Global innovation index for 2018

Country	*Business sophistication*	*Human capital and research*	*Knowledge and technology outputs*	*Infrastructure (Information & communication technologies (ICTs)*	*GLOBAL INNOVATION INDEX*
Azerbaijan	96	100	89	66	82
Iran	45	45	41	87	65
Kazakhstan	78	71	79	61	74
Malaysia	39	31	33	43	35
Russian Federation	33	22	47	63	46
Saudi Arabia	52	24	73	51	61
United Arab Emirates	23	29	53	28	38

Source: prepared by Author according to Global innovation index report for 2018

S. Vasin et al (2018) determine Kazakhstan at the stage of information economy in their key characteristics of the knowledge economy, which includes such indicators as the level of education, the average index of human development, internet covering and the level of the digital economy. At present, the government implements the State program on the industrial development of the Republic of Kazakhstan for years 2015 - 2019, which aims to promote diversification and competitiveness of the manufacturing industry. In this way, one of the main objectives of this study is to explore the efficiency of implementing the state Program on industrial innovation development empirically. This paper intends to look more closely at the character of the knowledge-based economy at the region level, to evaluate the efficiency of the state program and find out how strongly they are related to regional, national and international innovation systems.

Digital transformation strategies and programs are developed and implemented across countries, regions, cities, sectors, industries, and corporations, in this way the problems of legal regulation and self-regulation of digital economy come to the fore. D. Horvat et al. (2018) describe the case of Kazakhstan as an example for assessing the degree of readiness for Industry 4.0, in the aim of determining its state of development concerning the vision of Industry 4.0 and therefore fail to identify necessary fields of action, programs, and projects. Besides, recently it was launched State Program "Digital Kazakhstan" targets key areas like the development of a high-speed, secure digital infrastructure, the creation of competencies and skills for the digital economy and the digital transformation of the economy. Digitization of industrial production is not only beneficial for companies and governments in terms of economics, but can also provide clear benefits in environmental sustainability. In the framework of this research it will be investigated following hypotheses:

- Hypothesis 1: Knowledge economy indicators could be the main part of the regional economic development evaluation;
- Hypothesis 2: The role of industrial structure and specialization in regional economic growth is great;

– Hypothesis 3: Ecological effect is positively related to regional economic growth in the context of industry 4.0.

The paper will deal conceptually with the character of the knowledge-based economy and develop instruments for evaluation state measures. Its empirical part contains analysis for Kazakhstan based on data from the Statistics Committee of the Ministry of National Economy. From this analysis, conclusions will be drawn regarding the role of regional and other innovation systems for the development of knowledge-based industries.

1. LITERATURE REVIEW

A knowledge-based economy relies on knowledge as the key engine of economic growth. Parcero and Ryan (2016) assessed the performance of Qatar and the United Arab Emirates (UAE) in terms of their achievements towards becoming knowledge-based economies. It was implemented a comparison against 17 benchmark countries using a four pillars' framework comprising of (1) information and communication technology, (2) education, (3) innovation, and (4) economy and the regime in their research. They also described local programs, called Emiratization and Qatarization, which are being implemented and provide incentives for the private sector to absorb higher proportions of the national labor force growth. Lastly, both countries share the ambition to diversify their production systems away from oil and to become knowledge-based economies as well as leading regional/global players. This information also stated in the Qatar Vision 2030 and the UAE Vision 2021. Tan et al (2007) made research in evaluation the performances of the selected Asia Pacific countries using Data Enveloped Analysis (DEA) and revealed knowledge dissemination was the weakest point in developing knowledge-based economies. At this point, Wang et al (2008) described decision support system for evaluating state-owned enterprises using DEA models.

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 a 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. Sandrine Kergroach et al (2018) focus on policies aiming at fostering technology transfer and commercialization of public research in selected OECD and emerging economies, drawing on the recent EC/OECD STI Outlook Policy database. 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.

It has been pointed out (Zsófia, 2013) innovation performance in sectoral innovation systems depends on the nature of the industry and determined by its geographical location, which was concentrated on the subnational level, and influenced by regional innovation systems. In the framework of supporting incentives to induce firms to invest in research and improve the efficiency of innovation activities, governments try to solve this problem, using policy tools, such as R&D grants. However, the nature of the relationships among government support, private investment and innovation performance, particularly the effectiveness and efficiency of government R&D grants and private R&D funding, is an open question that requires an in-depth analysis (Hong, 2015).

M. Naser & R. Lawrey (2014) presented an evaluation of the efficient use of public research and development (R&D) expenditure in the ASEAN (Association of Southeast Asian Nations) region by using Data Envelopment Analysis (DEA). They demonstrate the importance of the efficient use of public R&D expenditure using a theoretical approach from the OECD and WBI knowledge economy frameworks and applying the DEA linear mathematical model. M. Namazi and E. Mohammadi (2018) examined how promotion of innovation in natural resource-rich economies can potentially insulate them from the resource curse with application of Data Envelopment Analysis (DEA) based on Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) in analyzing the innovative capabilities and readiness of natural resource-rich economies so that they don't fall into the trouble zone of the resources. Thus, literature review emphasizes evaluation the performances of the achievements towards becoming knowledge-based economies through impact of R&D investment, efficiency of innovation activities and ICT, however these models did not take into account the combination of the knowledge-based economy and industrial structure and specialization of the country.

2. METHODOLOGY

In addition to tracking knowledge economy-related variables, the OECD also established a formal definition of a "knowledge-based" economy and developed two concepts directly related to this newly defined construct (OECD, 2009): "Knowledge-based" industries were defined by the following characteristics: (1) a high-level investment in innovation, (2) intensive use of technology, and (3) a highly educated workforce. A knowledge-based Strategy is a strategy based on a high investment in qualified human resources (with high competence index and education index), and in general this is reflected in the fact that the company adopting a KS pays its employees more than the average of other companies appertaining to the same sector (Iazzolino et al, 2017). Furthermore, the basic aspects of human capital valuation are due to its key role in the economic development of modern enterprises, and the ability of human capital to influence the value of the company, as a special intangible asset (Czerewacz-Filipowicz & Kogut, 2019), that is why it was important to select such characteristics like science and knowledge workers. Combining a set of indicators into a composite index is a more recent trend in evaluation of technological capabilities, which is called into being by the growing complexity of science, technology and innovation, and their interplay with national economies (Fischer et al, 2019). In this case, the conceptual framework for the development of the knowledge economy can be represented in the form of the following schemes (figure 2):

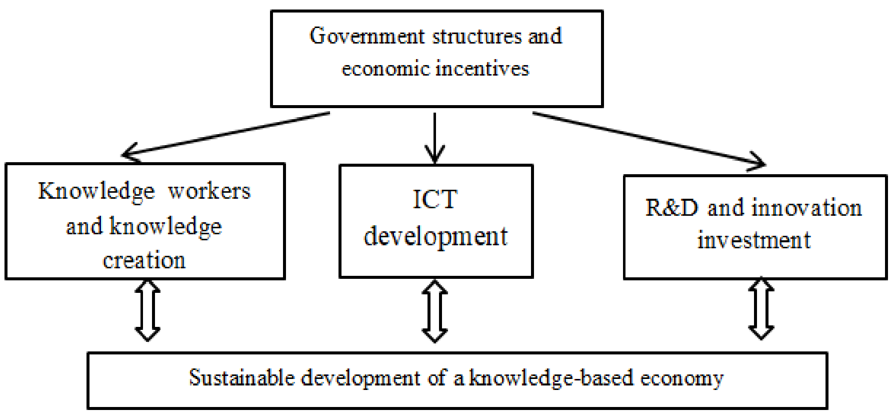

Figure 2. Conceptual framework for the development of the knowledge economy in the emerging countries

Source: prepared by Author

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. The regional level provides information as follows:

A. Innovation and technology level:
Innovative activity of organizations (the ratio of organizations implementing technological, organizational and marketing innovations to the total number of organizations) (InAcO);
The volume of innovative products (goods, services) (InnovProd);
B. R&D investments:
Internal expenditures on research and development (R&D) (R&Dexp);
Expenses for product and process innovations in the industry (EPIindustry);
Information technology expenses (ITexp);
C. Science and knowledge workers:
Number of organizations (enterprises) engaged in research and development (NOinR&D);
Number of employees engaged in research and development (NER&D);
The share of workers employed in high-tech industries (SWHT);
D. Knowledge creation:
Percentage of obtained patents and articles with impact factor per researcher (PPAR);
Share of patents in total research (SPTS);
E. Use of information and communication technologies (ICT):
Number of information technology specialists (NITS);
Number of organizations using the Internet (NOinternet);
The proportion of organizations using the Internet (POinternet);
Share of enterprises using new technologies in the total number of enterprises (SNTTE).

These 14 variables and indicators are model inputs characterizing the level of development of the knowledge economy in the region. The role of industrial structure and specialization in regional economic growth has been studied, earlier, from the perspective of regional exports (Kaldor 1970) and the cumulative causation mechanism which exports may cause to the regional growth (Dixon and Thirlwall 1975). To test how diversity and specialization of gross regional product affects regional growth, we use one of different types of indexes as explanatory variables in order to consider alternative aspects of industrial structure. Our measure is the conventional Herfindahl-Hirschman Index (HHI), which is formally the following: $HHI_i = \sum_{j=1}^{m}(X_{ij})^2$, where $X_{ij} = Y_{ij}/\sum_{j=1}^{m} Y_{ij}$ and Y_{ij} denotes the gross regional product in industry j in region i. The total number of all industries, which are included to the gross regional product each year, denotes m. In this specific form the HHI is an indicator of regional specialization. HHI was calculated according to the structure of industries, which made contribution to the gross regional product (table 2).

Table 2. Structure of industries, which included to the gross regional product in the aim of calculating HHI

Industry	*Year*
Agriculture, forestry and fisheries	2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017
Industry	2007, 2008, 2009, 2013, 2014, 2015, 2016, 2017
Mining and quarrying	2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017
Electricity, gas, steam and air conditioning	2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017
Education	2008,2009, 2014,2015,2016,2017
Financial and insurance activities	2008, 2009, 2014,2015,2016,2017
Water supply; sewage system, control over the collection and distribution of waste	2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017
Building	2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017

Wholesale and retail trade; car and motorcycle repair	2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017
Transportation and warehousing	2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017
Information and communication	2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017
Provision of other services	2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017
Manufacturing industry	2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017
Professional, scientific and technical activities	2014, 2015, 2016, 2017
Hotels and restaurants	2008, 2009

Source: prepared by Author

According to OECD report "Comprehensive overview of Kazakhstan" that, as the country with large part of mining and heavy industry, on the base of using electricity, which is produced mainly from coal in the structure of export, Kazakhstan is one of the most energy-intensive economies in the world, the energy intensity of production has not improved over the last decade. The environmental damage is exacerbated by the effects of energy production, pollution from heavy industry, intensive extraction of oil, gas and other minerals, as well as the development of rural farming, increasing traffic in cities. In this way, it was recommended to keep "environmental treatment" solutions for integrated pollution prevention and control. Because Integrated environmental permits are one of the most effective ways to control pollution since permitting associated with the best available technology associated with low emissions. Thus, emissions of air pollutants from stationary sources were chosen as a measure of ecological effect, which could impact regional economic growth. Stationary sources contain solids, gaseous and liquid substances (sulfurous anhydride, carbon monoxide, nitrogen oxides, hydrocarbons (without volatile organic compounds). 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.

Diversity of the data was normalized according to the function, which standardizes a given column of a matrix or data table so that it's arithmetic average is zero and the standard deviation is one. We run the following ordinary linear regression model 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 F-statistics test. GII report has already presented the innovation efficiency of countries simply by calculating the ratio of the average of innovation outputs to the average of innovation inputs (Cornell, 2015). For the following reasons DEA is more suitable than the simple efficiency ratio to analyze innovation performance:

- DEA approach takes into consideration the complex nature of innovation and accommodates multiple inputs and outputs in a single analysis.
- DEA does not assume nor require a judgment on the relative importance or weights of inputs and outputs.
- DEA can be used to set specific input and output targets for inefficient institutions based on the observed performance of the best practice institutions in the peer group. It focuses on optimal, not average, performance and sets input and output targets that are practical and attainable.

Although uncertainty in the DEA approach has been the subject of considerable research effort (Bruni et al. 2013, Gianpaolo Iazzolino et al., 2013). In recent years, tools like DEA have been utilized for determining MPI. At the second step of our research, we applied measurement of productivity of the state program to the development of knowledge-intensive economy using activity analysis models to construct Malmquist type productivity indexes. Although many periods are analyzed, and the change in technology over time is measured, these represent a fairly limited type of intertemporal models - one is essentially comparing a series of static models. Fare and Grosskopf (1996) illustrate how distance functions can readily aggregate in the case of many outputs and inputs and thus serve to construct productivity indexes, which are generally referred to as Malmquist productivity indexes.

According to the Fare and Grosskopf research (1996) recall that the output set P (x) denotes all output vectors that can be produced using the input vector x. Although the output distance function may be defined in terms of the graph or terms of the input set, here we choose to define it on P(x). The Output Distance Function is Do(x, y) = inf{B : (y/B) E P(x)}. In the most elementary case when a single input is employed to produce a single output, average products may be utilized to define total factor productivity. In particular, suppose we have data on a single input and output at two periods, denoted t and t + 1. Then Total Factor Productivity is defined as TFP = $\frac{\frac{y^{t+1}}{x^{t+1}}}{\frac{y^t}{x^t}}$

This productivity measure can be written as ratios of distance functions, i.e., as a Malmquist productivity index. In this text, we favor an output-oriented Malmquist productivity index defined as the geometric mean of the t and t+ 1-period indexes.

$$M_0(x^{t+1}, y^{t+1}, x^t, y^t) = \left[\frac{D_0^{t+1}(x^{t+1}, y^{t+1}|CRS)}{D_0^{t+1}(x^t, y^t|CRS)} \frac{D_0^t(x^{t+1}, y^{t+1}|CRS)}{D_0^t(x^t, y^t|CRS)}\right]^{1/2}$$

The "CRS" stands for constant returns to scale, and Fare and Grosskopf (1996) explicitly recognize that the distance functions are defined relative to CRS technologies. Farrell output-oriented measure of technical efficiency is the reciprocal of the output distance function, which is referred to as Efficiency Change. The square root of the second parenthetic expression captures shifts in the frontier of technology and is referred to as the Technical Change component. In general, the two-component measures are

Eff CH = $\frac{D_0^{t+1}(x^{t+1}, y^{t+1}|CRS)}{D_0^t(x^t, y^t|CRS)}$ and TECH = $\left(\frac{D_0^t(x^{t+1}, y^{t+1}|CRS)}{D_0^{t+1}(x^{t+1}, y^{t+1}|CRS)} \frac{D_0^t(x^t, y^t|CRS)}{D_0^{t+1}(x^t, y^t|CRS)}\right)^{1/2}$ respectively.

MI > 1 indicates progress in the total factor productivity of the DMU_o from period 1 to 2, while MI = 1 and MI < 1 respectively indicate the status quo and deterioration in the total factor productivity.

In our case, we used Malmquist Productivity Index in DEA to investigate the gross regional productivity performance of the knowledge-based indicators within regional specialization and ecological effect in the context of industry 4.0 taking into account the raw material economy orientation of the country. Based on the adopted methodological approaches, comparisons were carried out in ten periods: 2007 – 2008, 2008 – 2009, 2009 – 2010, 2010 – 2011, 2011–2012, 2012 – 2013, 2013 – 2014, 2014 – 2015, 2015 – 2016, 2016 – 2017. It was used a package in R "productivity" for both measures of technical efficiency by analyzing the shell of DEA and calculating changes in technical efficiency, characterized by the Malmquist index.

3. EMPIRICAL DATA AND ANALYSIS

We run the following OLS regression in order to achieve the objectives of the paper and used F-statistic and t-statistics in the purpose of test hypotheses, which was implemented in R. Table 1 presents the results of the linear regression (OLS) on the dependent variable "proportion of regions in the GRP".

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	-0.846	0.39904	-0.550	0.5834
Initial R&D expenses *(R&Dexp)*	4.965	2.13e-06 ***	7.297	1.91e-11 ***
Innovative activity of organizations *(InAc)*	-1.132	0.259567		
Expenses for product and process innovations in the industry *(EPI-industry)*	1.016	0.311683		
The volume of innovative products (goods, services) *(InnovProd)*	-0.546	0.5862		
Number of organizations (enterprises) engaged in R&D *(NOinR&D)*	3.713	0.000303 ***	6.694	4.67e-10 ***
Number of employees engaged in R&D *(NER&D)*	-1.494	0.1377	-1.908	0.0583.
Number of information technology specialists *(NITS)*	0.282	0.7782		
Information technology expenses *(ITexp)*	3.154	0.002007 **	4.0	0.000101 ***
Number of organizations using Internet *(NOinternet)*	1.791	0.075683 .		
The share of workers employed in high-tech industries *(SWHT)*	-0.976	0.3307		
Percentage of obtained patents and articles with impact factor per researcher *(PPAR)*	-3.282	0.001328 **	-3.504	0.000614 ***
Share of patents in total research *(SPTS)*	0.297	0.766817		
The proportion of organizations using the Internet *(POinternet)*	-0.750	0.454541		
Share of enterprises using new technologies in the total number of enterprises *(SNTTE)*	3.505	0.000628 ***	3.481	0.000663 ***
Herfindal-Hirschman Index of specialisation gross regional product (HHI)	4.976	2.03e-06 ***	6.971	1.09e-10 ***
Emissions of air pollutants from stationary sources (EIPSS)	4.595	1.01e-05 ***	5.712	6.29e-08 ***
Observations	165	165	165	165
Adjusted R^2	0.8876		0.8776	
p - value	2.2e-16		2.2e-16	
F-statistics	72.54 on 16 and 129 DF		153.6 on 7 and 142 DF	

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

Source: prepared by Author

As expected, there is a positive and highly significant effect from R&Dexp, which means that the level of financial investment does strongly influence the share of the proportion of regions in the GRP. Interestingly, number of organizations (enterprises) engaged in R&D and share of enterprises using new technologies in the total number of enterprises) are more present than other knowledge-based indicators. It may signal that Herfindal-Hirschman Index of specialization gross regional product and Emissions of air pollutants from stationary sources are both give the great contribution to the gross regional product, which can be explained by the structure of export, oriented to raw material production. So, Hypothesis 2 and Hypothesis 3 about the role of industrial structure and specialization in regional economic growth and ecological effect to regional economic growth were approved. With respect to the region level analysis, we found that “knowledge-based” characteristics, which were selected by regression model, observed three (R&Dexp, NER&D, SNTTE) variables that give significant impact to the gross regional product proportion of each region.

Table 2 presents the regression results of reduced model with factors, which showed some level of significance and get influence on the dependent variable. With respect to the gross regional product, we found that that the coefficients of all factors are statistically significant at 0,1%. However, comparing adjusted R^2 of these two models, we decided to use selected factors with the highest significance level of model 1. At the result of applying the Malmquist Productivity Index in DEA, we have got the following average values technical efficiency indicators for each year (table 3), which could be explained by several state measures.

Table 2. Average values technical efficiency indicators of economic regional growth

Period of time	*Technical efficiency score*	*Efficiency change*	*Malmquist productivity index*
2008 relative to 2007 (Q1)	0,845	0,945	0,791
2009 relative to 2008 (Q2)	1,129	1,056	1,166
2010 relative to 2009 (Q3)	1,086	0,951	1,03
2011 relative to 2010 (Q4)	0,885	1,041	0,92
2012 relative to 2011 (Q5)	0,805	0,963	0,767
2013 relative to 2012 (Q6)	0,936	1,045	0,973
2014 relative to 2013 (Q7)	0,823	1,034	0,852
2015 relative to 2014 (Q8)	0,976	0,981	0,958
2016 relative to 2015 (Q9)	0,989	1,016	1,006
2017 relative to 2016 (Q10)	1,012	0,98	0,993

Source: prepared by Author

It was passed a law about state supporting of innovation activity in the Republic Kazakhstan in 2006, which determined further steps to create appropriate infrastructure, particularly, development the network of technology parks and innovation funds, to introduce a mechanism for providing grants for the development of technological and product innovations. In the framework of the state program for the 2006-2008 period, policymakers identified such investment priority as information technologies, alternative energy sources, biotechnologies and pharmaceuticals, new materials, nanotechnologies, new technologies for the hydrocarbon sector and related service industries. At the result of these measures, it had been operated six regional technoparks, 12 technology business incubators, and service technology centers, six special economic zones operated in the Republic of Kazakhstan. According to these events, it is obvious that Technical efficiency score (1,12; 1,086) and Malmquist productivity index (1,166;1,03) revealed a score of more than 1. The falling world price for hydrocarbons and metals at the end of 2008 and the beginning of 2009 became a serious threat to the stability of the national economy: the decline in budget revenues affected the execution of social programs. Regarding table Technical efficiency score and Malmquist productivity index showed ineffective knowledge-based performance during the next six years period from 2010 to 2016.

The leadership of Kazakhstan has intensified the policy of diversifying the economy since 2010. The five-year state "Forced Industrial-Innovative Development Program" began to operate, aimed at significantly accelerating the development of the manufacturing industry and increasing the productivity of labor. In this way, as a resumption the state program of industrial-innovative development of the Republic of Kazakhstan for 2015–2019 was launched, which focused on developing manufacturing industry with a concentration of efforts and resources on a limited number of sectors, regional specialization using a cluster approach and effective sectoral regulation.

At the same time, innovative clusters were created that contributed to the formation of new competitive advantages of the country in the global market (knowledge cluster, global technological outsourcing) based on the creation of previously high-tech industries and sectors of the economy, new technological competencies, ensuring innovative breakthroughs. At the end of 2017, the state program "Digital Kazakhstan" was approved, taking into account the fact that the digital revolution is changing the current modes of production, the supply chain, and the value chain. Industry 4.0 serves as a driver for the digital industrial transformation. According to these changes, it can be seen, Malmquist productivity index (1,006) is more than 1 in 2016, and technical efficiency score (1,012) is more than 1 in 2017, which illustrated the improvement in the growth of the gross regional product.

CONCLUSION

Oil-exporting countries are struggling to spend their resources to push innovation as an enabler for their economic growth. However, optimal innovative solutions need to be addressed because efficiency is a vital element to achieve such a blessing from rich national resources (Shuai and Lili, 2014). Hence, oil-exporting countries need to support their efficiency system for consuming resources as little as possible to gain higher levels of innovation and knowledge-intensive productions. The level of Global innovation index varies from country to country. However, 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 Malmquist Productivity Index in DEA approach to evaluate 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 within HHI of specialization.

Even though the level of state support of R&D expenses for the whole country has increased, but in the conditions of the economic crisis, this was not enough. In other words, effective adequate anti-crisis measures about regions in 2010-2016 were not applied. The problems that arose were solved at the expense of the internal reserves of the regions, which were not included nature resources by its geographical location. That is why the technical efficiency of weak regions sharply worsened, where these reserves were practically absent (appendix 1).

Future investigations could also address the interesting issue of determining the relative weight of performance dimensions and indicators of innovation capability and the process of knowledge management using the AHP method.

REFERENCES

Bruni, M.E., Beraldi, P., Lazzolino, G. (2013) “Lending decisions under uncertainty: a DEA approach”, *International Journal of Production Research*, Vol. 52, No. 3, pp. 766–775.

Cornell, U. (2015), *The Global Innovation Index 2015: Effective Innovation Policies for Development*, INSEAD, & WIPO, Ithaca, and Geneva.

Cornell, INSEAD, WIPO (2017), *The Global Innovation Index 2017: Innovation Feeding the World*, Ithaca, ed. S. Dutta, B. Lanvin, and S. Wunsch-Vincent, Fontainebleau, and Geneva.

Czerewacz-Filipowicz, K., Kogut, O.Y. (2019), “Comprehensive methodology for assessing human capital and problems of its assessment”, *The Journal of Economic Research & Business Administration*, No. 1 (127), pp. 286-298.

Dixon R, Thirlwall A.P. (1975), “A model of regional growth rate differentials along Kaldorian lines”, *Oxford Economic Papers* , Vol. 27, pp. 201–214.

Färe R., Grosskopf S. (1996), *Intertemporal Production Frontiers: With Dynamic DEA*, Springer Eds.

Fischer B.B, Kotsemir M., Meissner D., Streltsova E. (2019), “Patents for evidence-based decision-making and smart specialisation”, *The Journal of Technology Transfer*, article in press.

Horvat D., Stahlecker T., Zenker A., Lerch C., Mladineo M. (2018), “A conceptual approach to analysing manufacturing companies’ profiles concerning Industry 4.0 in emerging economies”, 28th International Conference on Flexible Automation and Intelligent Manufacturing (FAIM2018), June 11-14, 2018, Columbus, OH, USA.

Heshmati, A., Shiu, A. (2006) “Technical Change and Total Factor Productivity Growth for Chinese Provinces: A Panel Data Analysis”, *IZA Discussion Papers*, No. 2133.

Hong, J. (2015) “Government grants, private R&D funding and innovation efficiency in a transition economy”, *Technology Analysis & Strategic Management*, Vol. 27, No. 9, p.1068–1096.

Iazzolino, G., Bruni, M.E., Beraldi P. (2013), “Using DEA and financial ratings for credit risk evaluation: an empirical analysis”, *Applied Economics Letters*, 2013, Vol. 20, No. 14, 1310–1317.

Lazzolino, G., Laise D., Rossella G. (2017), "Knowledge-based strategies and sustainability: a framework and a case study application", *Measuring Business Excellence*, Vol. 21 Iss. 2, pp. 152 – 174, doi: 10.1108/MBE-11-2015-0050.

Kaldor N. (1970), “The case for regional policies”, *Scottish Journal of Political Economy,* Vol. 18, pp. 337–348.

Kergroach, S. et al. (2017) “Technology transfer and commercialization by universities and PRIs: benchmarking OECD country policy approaches”, *Economics of Innovation and New Technology*, Vol. 27, No. 5–6, pp. 510–530, doi: 10.1080/10438599.2017.1376167.

Kitous, A.G. et al. (2016), *Impact of Low Oil Prices on Oil Exporting Countries. European Commission*, DG Joint Research Centre (JRC), Sevilla, Spain.

Kozhakhmetova, A.K., Gabdullin, K.T., Kunanbayeva, D.A., Tazhiyeva, S.K., Kydaybergenova, R.E. (2019), “Green Energy Project`s Efficiency: A Cross-industry Evaluation”, *International Journal of Energy Economics and Policy*, Vol. 9, No. 5, pp. 207-215.

Kupeshova, S., Orynbassar, A., (2018), “The role of government in the development of innovative activity in the Republic of Kazakhstan", *The Journal of Economic Research & Business Administration*, No. 2 (124), pp. 46-56.

Naser, M., Lawrey, R. (2014) “Measuring the importance and efficiency of research and development expenditures in the transformation of knowledge-based economies: a case study of the Asian region”, *IJAPS*, Vol. 10, No. 1, pp. 33-47.

Namazi, M., Mohammadi, E. (2018) “Natural resource dependence and economic growth: A TOPSIS/DEA analysis of innovation efficiency”, *Resources Policy*, ol. 59 (2018), pp. 544-552, doi: 10.1016/j.resourpol.2018.09.015.

Organization for Economic Cooperation and Development (2009), *OECD Science, Technology, and Industry Scoreboard*.

Parcero, O.J., Ryan, JC. (2016) “Becoming a Knowledge Economy: the Case of Qatar, UAE, and 17 Benchmark Countries”, Journal of the knowledge economy, VOL. 8, No. 4, pp. 1146-1173, doi: 10.1007/s13132-016-0355-y.

Sabah, M.J.A.A. Al, (2013), *Resource Curse Reduction through Innovation – A Blessing for All – The Case of Kuwait*, Cambridge Scholars Publishing, Newcastle.

Sagiyeva, R., Zhuparova, A., Ruzanov, R., Doszhan, R., Askerov, A. (2018), “Intellectual input of development by knowledge-based economy: problems of measuring in countries with developing markets", *The International Journal Entrepreneurship and Sustainability Issues*, Vol. 6, No. 2, pp. 711-728.

Sleire, S. (2017), "World's Biggest Wealth Fund Wants Out of Oil and Gas", Bloomberg, https://www.bloomberg.com/news/articles/2017-11-16/norway-s-1-trillion-wealth-fund-wants-out-of-oil-and-gas-stocks)).

Tan H.B., Hooy C.W., Islam S. M. N., Manzoni A. (2007), "Modelling the Efficiency of Knowledge Economies in the Asia Pacific: a DEA Approach", *Proceedings of the 2007 IEEE IEEM, 2000-2004*.

Vasin S., Gamidullaev L., Shkarupeta E., Palatkin I., Vasina T., (2018), "Emerging Trends and Opportunities for Industry 4.0 Development in Russia", *European Research Studies Journal,* Volume XXI, Iss.3, pp. 63-76;

Wang, Wei-Kang, Huang, Hao-Chen and Lai, Mei-Chi (2008) "Desing of a knowledge-based performance evaluation system: A case of high-tech state-owned enterprises in an emerging economy", *Expert Systems with Applications*, Vol. 34, pp. 1795-1803.

World's top export, http://www.worldstopexports.com/worlds-top-oil exports-country>.

Zhuparova, A., Sagiyeva, R., Zhaisanova, D. (2018) "Using the Case Study Method in Studying the National Innovation System: Cross-Country Comparative Analysis", *Proceedings of the 13th European Conference on Innovation and Entrepreneurship*, 20-21 September, Aveiro, Portugal, pp. 883-892.

Zsófia, V. (2013) "Evidence on Knowledge-intensive Industries in the Regional Innovation System of the Southern Great Plain", *Regional Growth, Development and Competitiveness*, pp. 215-231.

APPENDIX

Table A1. Technical efficiency score

Region	*Q1*	*Q2*	*Q3*	*Q4*	*Q5*	*Q6*	*Q7*	*Q8*	*Q9*	*Q10*
Akmola region	1,12	1,28	1,15	0,69	0,93	0,92	0,79	0,92	1,05	0,86
Aktobe region	0,93	0,83	1,17	0,96	0,96	0,93	0,73	0,85	0,95	1,08
Almaty region	0,91	1,79	0,99	0,83	1,03	1,10	0,82	1,11	0,89	1,23
Atyrau region	0,66	inf	0,5	0,97	0,67	1,23	0,57	0,9	1,55	0,83
West Kazakhstan region	1,46	0,71	1,4	0,64	1,02	0,68	0,74	1,16	0,86	1,62
Zhambyl region	1,10	inf	1,17	0,86	1,18	0,72	0,81	0,94	1,05	0,89
Karagandy region	0,75	1,17	1,56	0,68	0,81	0,82	0,98	0,89	1,36	1,03
Kostanay region	0,9	0,94	1,13	0,94	0,91	0,81	0,86	0,94	0,94	0,85
Kyzylorda region	0	inf	1,00	0,9	0	0,83	0,74	0,80	0,74	0,97
Mangystau region	1,37	0,96	1,08	0,74	0,7	0,87	0,88	0,90	1,06	1,13
Pavlodar region	0,54	1,06	1,25	0,86	0,97	0,93	1,04	1,05	0,75	0,99
North Kazakhstan region	1,15	inf	0,95	1,2	0,53	1,03	0,85	0,92	1	0,85
East Kazakhstan region	0,69	0,83	1,19	0,97	0,80	0,98	0,90	1,02	0,9	0,99
Astana	0,53	1,5	0,91	0,91	0,88	0,93	0,93	1,28	0,97	1,05
Almaty	0,57	1,36	0,85	1,15	0,71	1,28	0,72	0,96	0,75	0,82

Table A2. Efficiency change

Region	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Akmola region	0,79	1,27	0,74	1,35	0,68	1,28	1,06	0,91	1,2	0,79
Aktobe region	1,0	0,94	0,99	1,08	1,0	1,0	1,0	0,99	1,02	0,86
Almaty region	1,0	1,0	0,99	0,99	1,02	0,88	1,13	1,0	1,0	1,0
Atyrau region	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0
West Kazakhstan region	1,0	1,0	1,0	1,0	1,0	0,95	1,06	1,0	1,0	1,0
Zhambyl region	0,8	1,25	0,8	1,12	0,73	1,28	1,15	0,87	1,13	1,07
Karagandy region	0,98	1,03	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0
Kostanay region	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	0,96	1,01
Kyzylorda region	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	0,95
Mangystau region	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0
Pavlodar region	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0
North Kazakhstan region	0,88	1,14	0,9	1,12	1,0	1,0	1,0	1,0	1,0	1,0
East Kazakhstan region	0,74	1,35	0,88	1,14	1,0	0,97	1,03	0,95	0,94	1,02
Astana	1,0	0,85	0,98	0,83	1,01	1,32	1,1	1,0	1,0	1,0
Almaty	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0

Table A3. Malmquist productivity index

Region	*Q1*	*Q2*	*Q3*	*Q4*	*Q5*	*Q6*	*Q7*	*Q8*	*Q9*	*Q10*
Akmola region	0,88	1,63	0,85	0,94	0,63	1,17	0,84	0,84	1,26	0,68
Aktobe region	0,93	0,77	1,16	1,04	0,96	0,93	0,73	0,84	0,96	0,93
Almaty region	0,91	1,79	0,98	0,82	1,06	0,97	0,93	1,11	0,89	1,23
Atyrau region	0,66	inf	0,5	0,97	0,67	1,23	0,57	0,9	1,55	0,83
West Kazakhstan region	1,46	0,71	1,4	0,64	1,02	0,65	0,78	1,16	0,86	1,62
Zhambyl region	0,88		0,93	0,95	0,86	0,93	0,93	0,82	1,19	0,96
Karagandy region	0,73	1,2	1,56	0,68	0,81	0,82	0,98	0,89	1,36	1,03
Kostanay region	0,9	0,94	1,13	0,94	0,91	0,81	0,86	0,94	0,9	0,86
Kyzylorda region	0		1,0	0,9	0,0	0,83	0,74	0,8	0,74	0,93
Mangystau region	1,37	0,96	1,08	0,74	0,7	0,87	0,88	0,9	1,06	1,13
Pavlodar region	0,54	1,06	1,25	0,86	0,97	0,93	1,04	1,05	0,75	0,99
North Kazakhstan region	1,01	inf	0,85	1,34	0,53	1,03	0,85	0,92	1,0	0,85
East Kazakhstan region	0,51	1,13	1,05	1,1	0,8	0,95	0,93	0,97	0,86	1,01
Astana	0,53	1,27	0,89	0,75	0,89	1,22	1,01	1,28	0,97	1,05
Almaty	0,57	1,36	0,85	1,15	0,71	1,3	0,72	0,96	0,75	0,82