Evaluation of the Comparative Effectiveness of Fiscal Measures and Supply Chain Strategy at Stimulating Oil Production from 2010 to 2016 Carried Out with the ε-KAM Mathematical Model

V. V. Ponkratov [*1], A. K. Karaev[2], A. I. Masterov[3], S. V. Anureev[4], A. S. Lozhechko[5]

[1,2,3,4,5]*Financial University under the Government of the Russian Federation,*
[1]*ponkratovvadim@yandex.ru*

Abstract. **The article evaluates the effectiveness of measures of supply chain management and national fiscal policies aimed at stimulating oil production in several countries (the USA, Canada, Brazil, Norway and Russia). Calculations were carried out with the ε-KAM mathematical model using the data for the period from 2010 to 2016. The model includes the following: the input indicators are budget transfers and tax benefits for oil producers, and the output indicators are the average annual volumes of oil production. Regarding the price efficiency of fiscal policy aimed at stimulating oil production in 2010–2016, Russia showed the lowest result. At the same time, Russia demonstrated the highest efficiency of using budget transfers to stimulate oil production, and Canada achieved the greatest efficiency in applying tax measures.**

Keywords: *fiscal policy measures, supply chain management, stimulating oil production, cross-country analysis, ε-KAM model.*

1. Introduction

Along with Canada, the USA, Brazil and Norway, Russia is one of the leading oil and gas producers and has large hydrocarbon reserves. A recent study by the World Wildlife Fund (WWF) and the Global Subsidies Initiative of the International Institute for Sustainable Development (IISD) analyzed economic, social and environmental efficiency and the feasibility of subsidizing oil and gas production in some G20 countries, including Russia [1, 2]. Undoubtedly, Russia offers great state support for oil and gas producers [3]. It is hard to overestimate the importance of these companies for the Russian budget. Therefore, to support and control them, the country needs a wide range of economic, financial and other instruments, including subsidies that were explored in this study [4]. The authors analyzed oil and gas subsidies existing in Russia in accordance with the international methodology developed by the Global Subsidies Initiative of the International Institute for Sustainable Development. Additionally, the study identified various forms of state support for Russian oil and gas producers: direct or indirect budget financing, tax benefits, damage compensation, support for prices and revenues of companies, the provision of state-owned resources, and government services at prices lower than the market ones. Estimates of these subsidies in monetary terms are given for the period from 2009 to 2010. In general, energy subsidies are actively and widely applied throughout the world [5, 6, 7]. Moreover, they are popular in both developed and developing countries. Emerging market economies in Asia account for about half of the total subsidies, while developed economies use about a quarter of these. In absolute terms, the largest subsidies can be found in China (USD 2.3 trillion), the USA (USD 699 billion), Russia (USD 335 billion), India (USD 277 billion), and Japan (USD 157 billion). The European Union also has quite large subsidies (USD 330 billion). The budgetary implications of energy subsidies were estimated at USD 5.3 trillion in 2015, and they exceed the estimated amount of public health spending worldwide. These subsidies are also higher than the global spending on investment [8]. Resources released through subsidy reform can be allocated to meet urgent needs of public spending [9] or to reduce taxes hindering economic growth. Due to such popularity and active use of energy subsidies, it seems viable to consider their comparative effectiveness in some countries specializing in oil production (the USA, Canada, Norway, Brazil, and Russia) for the period from 2010 to 2016.

IJSCM, ISSN: 2050-7399 (Online), 2051-3771 (Print)

2. Methodology

In this paper we will use the ε-KAM model to evaluate the comparative efficiency of budget funds allocated to increase oil production in the above countries. Data Envelopment Analysis (DEA) is currently considered to be the main method for comparative study of the effectiveness of government activities in particular countries or regions (more commonly referred to as Decision Making Units, DMU). A detailed description of this method can be found in [10], [11], and [12]. The detailed literature review is presented in [13], [14], and [15]. DEA method determines the production possibility frontier regarding "spent resources– resulting indicators" [16] and [17]. As a rule, budget expenditures for the provision of certain public goods are considered as input data. The achieved level of public welfare in a particular area is the output. DMU itself can be represented as points in space, with input and output indicators as their dimensions. DMU effectiveness is measured as the ratio between cost and outcome, estimated with the data of the most "productive" DMU in the considered group. DMUs with maximum output at minimum cost are reference (effective) ones and are used to determine the production possibility frontier. Although the ε-KAM mathematical model is based on the weighted additive DEA model (ADD), however, it is free from its major faults. The epsilon value can be changed from 0 to ∞. The measure in the KAM model has at least the same properties as the SBM model. Estimates given by the KAM model can be used to calculate technical efficiency as well as price efficiency. Thus, traditional DEA models (CCR, BCC, ADD, SBM, ERM and others) can measure the technical efficiency of a DMU, but cannot be used for benchmarking and ranking DMUs as for this it is necessary to know price efficiency of the compared DMUs. Using the ε-KAM model, one can evaluate both technical and price efficiency of the compared DMU. The authors of this article used one of the recent and most successful modifications of DEA method—KAM model that not only estimates the production possibility frontier, but also simultaneously determines performance and ranks DMUs according to their technical and price efficiency. Input and output indicators of the empirical (mathematical) ε-KAM model were selected using the methodology for evaluating the effectiveness of state scientific and innovative programs presented in the work of R. Melnikov [18]. He considered both Russian and international experience in this field. The main indicators used in other countries are grouped into a logical model for evaluating scientific and innovative programs developed by analysts of the Advanced Technology Program, the USA [19]. In accordance with this logical model, the effectiveness and efficiency of state research and innovation programs are evaluated by calculating four groups of indicators characterizing resource supply (input), immediate results of the program (output), medium-term results of the program (outcome) and broad consequences (impact).

3. Results and discussion

The authors chose the following input and output indicators of the ε-KAM mathematical model.

1) Indicators characterizing resource supply, also acting as input variables of the model:

X1is budget transfers, in 1000 units of the country's national currency, in current prices;

X2 is tax benefits for companies producing oil, in 1000 units of the country's national currency, in current prices;

2) Immediate results are output variables:

Y1 is the volume of oil produced, in million barrels per day, year average.

The numerical values of the selected indicators and indicators of the mathematical ε-KAM model for evaluating the comparative effectiveness of fiscal policy aimed at stimulating oil production from 2010 to 2016 in the USA, Canada, Norway, Brazil, and Russia are presented in Figures 1–5.

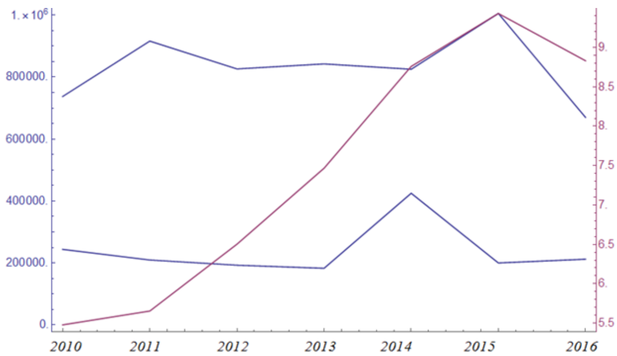

Figure 1. Dynamics of budget transfers, tax expenditures and oil production in the United States for the period from 2010 to 2016 (left scale – budget transfers and tax expenditures, thousand USD; right scale – daily oil production, year average, mln barrels/day)

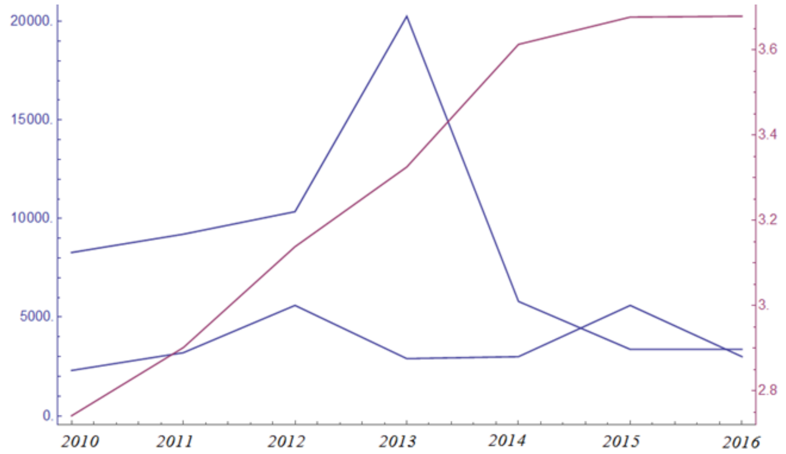

Figure 2. Dynamics of budget transfers, tax expenditures and oil production in Canada for the period from 2010 to 2016 (left scale – budget transfers and tax expenditures, thousand USD; right scale – daily oil production, year average, mln barrels/day)

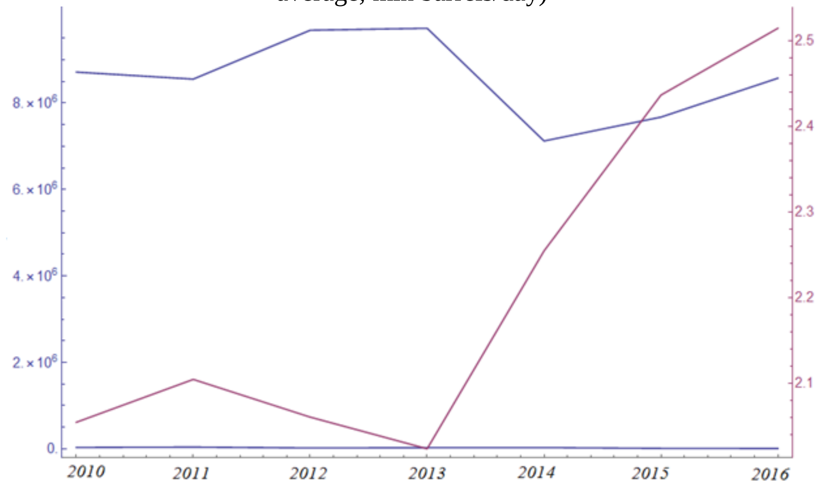

Figure 3. Dynamics of budget transfers, tax expenditures and oil production in Brazil for the period from 2010 to 2016 (left scale – budget transfers and tax expenditures, thousand USD; right scale – daily oil production, year average, mln barrels/day)

Figure 4. Dynamics of budget transfers, tax expenditures and oil production in Norway for the period from 2010 to 2016 (left scale – budget transfers and tax expenditures, thousand USD; right scale – daily oil production, year average, mln barrels/day)

Figure 5. Dynamics of budget transfers, tax expenditures and oil production in Russia for the period from 2010 to 2016 (left scale – budget transfers and tax expenditures, thousand USD; right scale – daily oil production, year average, mln barrels/day)

The indicators of the compared 35 decision-making units (DMUs) reflecting the funds spent are distributed in the following way: budget transfers and tax benefits, normalized to the volume of oil produced from 2010 to 2016, are presented in Figure 6 on a double logarithmic scale. More efficient DMUs are closer to the beginning of coordinates: they use fewer input financial resources per unit of output indicator – the volume of the produced oil. DMUs are numbered as follows: from 1 to 7 – the United States; from 8 to 14 – Canada; from 15 to 21 – Brazil; from 22 to 28 – Norway; and from 29 to 35 – Russia.

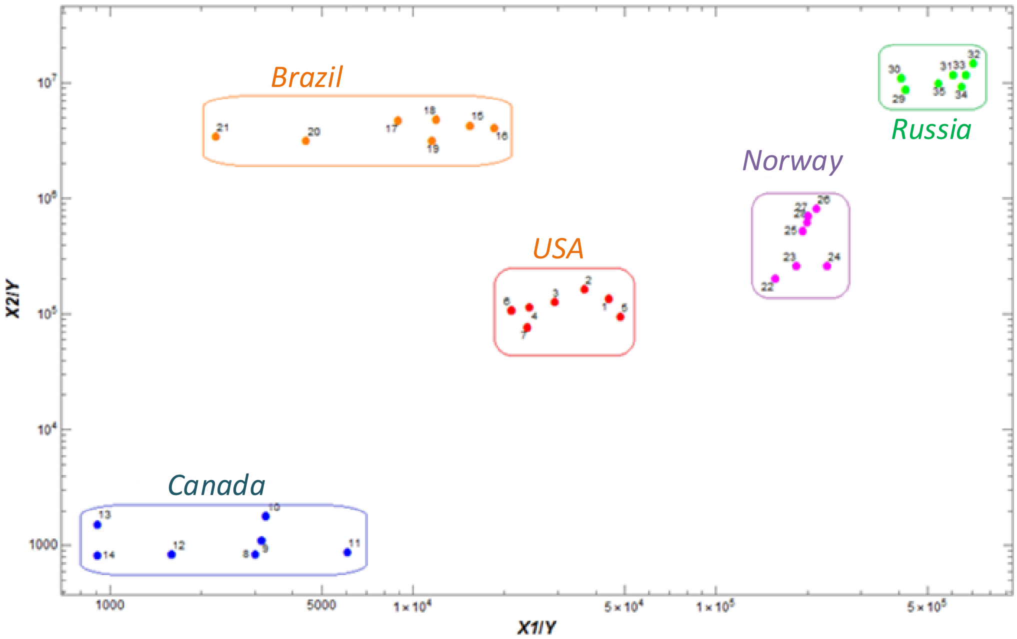

Figure 6. Distribution of the indicators of comparable decision-making units (DMU) in the space of the used funds: budget transfers and tax benefits, normalized to the volume of oil produced from 2010 to 2016, on a double logarithmic scale

Table 1 presents numerical estimates of the technical and price efficiency of the fiscal policy aimed at increasing oil production from 2010 to 2016, in the United States, Canada, Brazil, Norway and Russia. The results of computer calculations show that the following countries had the highest technical efficiency of fiscal policy aimed at increasing oil production from 2010 to 2016 with a comparative efficiency rating of 1.0: in the USA in 2015 and 2016, in Canada in 2010 and 2014, and in Russia in 2016. That is, the technical efficiency of fiscal measures to increase oil production in these countries in the specified period is on the production possibility frontier [20, 21, 22]. However, one should keep in mind that it is impossible to use technical efficiency assessments for ranking the compared DMUs. To rank these countries by the efficiency of fiscal measures aimed at increasing oil production over the period from 2010 to 2016, the authors used the relevant estimates of price efficiency (see Table 1, Column 7). Having analyzed the estimates of price efficiency of fiscal measures aimed at increasing oil production in the USA, Canada, Brazil, Norway, and Russia, the authors concluded that these measures were most effective in Canada in 2016 (the price efficiency of fiscal policy aimed at increasing oil production using ε-KAM equals one) [23].

Table 1. Annual budget fiscal support for oil producers (in national currencies, in current prices) and oil production (million barrels/day) in the USA, Canada, Brazil, Norway, and Russia from 2010 to 2016, with quantitative estimates of the comparative technical and price efficiency of fiscal measures aimed at increasing oil production in these countries

Indicators	X1-Budgetary Transfers, in national currency, 1000 units	X2- Tax Expenditure, in national currency, 1000 units	Y1- Petroleum Production, million barrels per day	KAM-score, e=10-7, Technical efficiency	KAM-score, e=10-2	KAM- score, e=10, Price efficiency
2010-USA	243 823	737 385	5.478	0.316	0.31	0.013
2011-USA	209 450	916 250	5.654	0.34	0.334	0.015
2012-USA	192 700	826 400	6.502	0.528	0.522	0.019
2013-USA	182 700	842 600	7.467	0.722	0.715	0.022
2014-USA	425 000	825 400	8.759	0.646	0.642	0.014
2015-USA	200 000	1 005 400	9.431	1.	0.988	0.025
2016-USA	212 000	670 000	8.831	1.	0.993	0.024
2010-CAN	8282	2300	2.741	1.	0.984	0.638
2011-CAN	9212	3200	2.901	0.514	0.513	0.514
2012-CAN	10 356	5600	3.138	0.367	0.367	0.367
2013-CAN	20 266	2900	3.325	0.563	0.557	0.543
2014-CAN	5800	3000	3.613	0.776	0.775	0.776
2015-CAN	3370	5600	3.677	0.768	0.767	0.767
2016-CAN	3370	3000	3.679	1.	1.	1.
2010-BRA	31 906	8 718 970	2.055	0.03	0.029	0.03
2011-BRA	39 234	8 556 409	2.105	0.025	0.024	0.024
2012-BRA	18 561	9 687 359	2.061	0.051	0.05	0.05
2013-BRA	24 317	9 733 410	2.024	0.038	0.038	0.038
2014-BRA	26 266	7 124 422	2.255	0.04	0.039	0.039
2015-BRA	10 920	7 677 705	2.437	0.102	0.102	0.102
2016-BRA	5649	8 577 940	2.515	0.204	0.203	0.204
2010-NOR	294 000	375 000	1.871	0.201	0.201	0.266
2011-NOR	326 000	460 000	1.76	0.177	0.178	0.21
2012-NOR	376 000	420 000	1.612	0.158	0.16	0.197
2013-NOR	297 000	806 000	1.533	0.143	0.144	0.156
2014-NOR	337 000	1 270 000	1.562	0.115	0.115	0.115
2015-NOR	327 000	1 125 000	1.61	0.129	0.129	0.129
2016-NOR	330 000	1 020 000	1.648	0.139	0.139	0.139
2010-RUS	4.11312×10^6	8.27562×10^7	9.694	0.334	0.224	0.031
2011-RUS	4.01778×10^6	1.06478×10^8	9.774	0.388	0.289	0.031
2012-RUS	6.03577×10^6	1.14532×10^8	9.922	0.418	0.341	0.022
2013-RUS	7.14095×10^6	1.47353×10^8	10.054	0.427	0.364	0.019
2014-RUS	6.78586×10^6	1.18339×10^8	10.107	0.526	0.455	0.02
2015-RUS	6.65043×10^6	9.4842×10^7	10.253	0.722	0.641	0.022
2016-RUS	5.76249×10^6	1.02983×10^8	10.551	0.999	0.917	0.025

4. Conclusion

According to Table 1, Russia demonstrated the least efficient fiscal policy with the lowest level of comparative price efficiency of the measures aimed at increasing oil production over the period from 2010 to 2016 (estimates of price efficiency are less than 0.1). The calculation results also show that between these two fiscal stimulus measures for oil production growth—budget transfers and tax expenditures, during the observation period from 2010 to 2016, among all the countries considered, Russian government policy of using budget transfers was best at stimulating oil production growth (the correlation coefficient of budget transfers and oil production over the observation period is more than 0.6, while for other countries this indicator is much lower, for instance, in the USA this indicator is less than 0.3). As for the tax measures aimed at increasing oil production, the research results for the reviewed countries show that tax measures in Canada most efficiently stimulate the growth of oil production (the correlation coefficient between tax expenditures and oil production for the observation period is over 0.3, while for other countries this indicator is lower, for example, for Russia this indicator is less than 0.2).

References

[1] Whitley, S., Chen, H., Doukas, A., Gencsu, I., Gerasimchuk, I., Touchette, Y., Worrall, L. *G7 fossil fuel subsidy scorecard: tracking the phase-out of fiscal support and public finance for oil, gas and coal*. Briefing papers. June. https://www.odi.org/publications/11131-g7-fossil-fuel-subsidy-scorecard, 2018.

[2] Vasiljeva, M. V., Ponkratov, V. V., Kharlamova, E. Y., Kuznetsov, N. V., Maramygin, M. S., Volkova, M. V. *Problems and prospects of development of the oil exchange market in the Russian Federation.* International Journal of Energy Economics and Policy, 9(3), 77-86, 2019.

[3] Ponkratov, V., Pozdnyaev, A., Kuznetzov, N. *Evaluating the impact of Russian excise duty on oil products on the development of oil refining and oil industry*. European Research Studies Journal, 21(4), 414-425, 2018.

[4] Gerasimchuk, I. V. *State support for oil and gas production: at what price?* https://www.iisd.org/sites/default/files/publications/ffs_awc_russia_ru.pdf

[5] Ponkratov, V. *Oil production taxation in Russia and the impact of the tax maneuver*. Journal of Tax Reform, 1(1), 100-112, 2015.

[6] Muda, I., Erlina, Omar, N. H., Said, J., Kholis, A. *The constraints and barriers for loan distribution by financing institutions to*

cooperant members. Journal of Southwest Jiaotong University, 54(3). http://jsju.org/index.php/journal/article/view/280, 2019.

[7] Shtiller, M.V., Appakova, G.N., Selezneva, I.V., Vasiljeva, M.V., Sisina, N.N. *Procedure for efficiency assessment of financial - Budgetary control system.* Journal of Applied Economic Sciences, 12(8), 2442-2454, 2017.

[8] Ponkratov, V. V., Pozdnyaev, A. S. *Taxation of oil production in Russia –consequences of tax maneuvers*. Oil industry, 3, 24-27, 2016.

[9] Chikunov, S. O., Ponkratov, V. V., Sokolov, A. A., Pozdnyaev, A. S., Osinovskaya, I. V., Ivleva, M. I. *Financial risks of Russian oil companies in conditions of volatility of global oil prices*. International Journal of Energy Economics and Policy, 9(3), 18-29, 2019.

[10] Akhremenko, A. *Efficiency and Effectiveness in Russian Regional Healthcare. In Russia's Regions and Comparative Subnational Politics*. L., NY: Routledge, pp. 120-140, 2013.

[11] Onrubia-Fernández, J., Sánchez Fuentes, A. J. *How costly are public sector inefficiencies? A theoretical framework for rationalizing fiscal consolidations.* Economics: The Open-Access, Open-Assessment E-Journal, 11 (35), 1-19. http://dx.doi.org/10.5018/economics-ejournal.ja.2017-35, 2017.

[12] Muda, I., Landau, S. N., Erlina. *The implementation theory of conservative accrual accounting to the quality of accounting information systems.* Journal of Southwest Jiaotong University, 54(1). http://jsju.org/index.php/journal/article/view/266, 2019.

[13] Muhammad K. *The Effects of Electronic Human Resource Management on Financial Institutes*. Journal of Humanities Insights. 02(01): 01-5, 2018.

[14] Emrouznejad, A., Parker, B., Tavares, G. *Evaluation of Research in Efficiency and Productivity: a Survey and Analysis of the First 30 Years of Scholarly Literature in DEA*. Socio-Economic Planning Science, 42(3), 151-157, 2008.

[15] Coelli, T. *An Introduction to Efficiency and Productivity Analysis*. Springer, 2005.

[16] Commission on Growth and Development. *The Growth Report: Strategies for Sustained Growth and Inclusive Development*. http://siteresources.worldbankorg/EXTPREMNET/Resources/489960-1338997241035/Growth_Commission_Final_Report.pdf, 2008.

[17] Cooper, W., Seiford, L., Tone, K. *Data Envelopment Analysis*. A Comprehensive Text with Models, Applications, References and DEA-Solver Software, Springer, 2006.

[18] Arcelus, F., Arocena, P. *Productivity Differences across OECD Countries in the Presence of Environmental Constraints*. Journal of the Operational Research Society, 56, 1352-1362, 2005.

[19] Maudos, J., Pastor, J., Serrano, L. *Human Capital in OECD Countries: Technical Change, Efficiency and Productivity.* International Review of Applied Economics, 17, 419-435, 2003.

[20] Melnikov, R. M. *International approaches to assessing the effectiveness of public investment in the implementation of research and innovation programs and the potential of adopting them in the Russian context*. Economic Analysis: Theory and Practice, 2016, 5, 112-123.

[21] Ruegg, R., Feller, I. *A toolkit for evaluating public R&D investment. Models, methods, and findings from ATP's first decade*. Gaithersburg: National Institute of Standards and Technology, 2003.

[22] Plenkina, V. V., Osinovskaya, I. V. *Improving the system of labor incentives and stimulation in oil companies.* Entrepreneurship and Sustainability Issues, 6(2), 912-926, 2018.

[23] Bloshenko, T. A., Ponkratov, V. V., Pozdnyaev, A. S. *Methodology for identifying the differentiated mineral extraction tax rates relating to the recovery of solid minerals*. Journal of Environmental Management and Tourism, 8(1), 60-66, 2017.