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TRANSIT TARIFF OPTIMIZATION MODEL FOR RUSSIA AND CENTRAL ASIA ENERGY COOPERATION

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Abstract. The purpose of this article is to develop an optimization model for determining transit tariffs for energy resources, ensuring maximum efficiency of energy cooperation between Russia and the countries of Central Asia. The informational basis of the study was the statistical values of the indicators in the context of the countries studied for 2010-2017: gross domestic product (GDP), exports, energy imports, CO_2 emissions, the level of transit tariffs for oil and gas. In order to achieve the objectives set by the method of multidimensional factor and integral analysis, the effectiveness of export-import relations between the studied countries was evaluated. The regression analysis method determined the elasticity coefficients of the export-import potential of countries and the transit tariff, with their impact on the efficiency of energy trade. Using a non-linear method of the generalized decreasing gradient, a model has been developed for calculating the optimal levels of transit tariffs for oil and gas, at which maximum efficiency of energy cooperation in the framework of export-import operations between Russia and Central Asia is achieved. The developed model for calculating the optimization of transit tariffs for hydrocarbons is based on the mutual reduction of their level between countries and the principle of equivalence. Practical application of the obtained optimal values of transit tariffs will ensure the intensification of export-import operations with hydrocarbons between countries on mutually beneficial economic conditions. It will be the basis for the development of effective strategies for the development of dense energy cooperation in the future.

Keywords: energy cooperation; transit tariffs; energy resources; Russia; Central Asia

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JEL Classifications: Q4, H21, F1

1. Introduction

A multitude of inter-governmental bilateral or multilateral agreements signed by Russia and the former Soviet countries in Central Asia focuses on mutual economic cooperation. Cooperation in the energy sector is a high priority (The Ministry of Foreign Affairs of the Russian Federation, 2008; The Ministry of Foreign Affairs of the Russian Federation, 2018). Russia, Kazakhstan, Uzbekistan, and Turkmenistan (as the largest producers of traditional energy in Central Asia) are interested in maximizing their benefits from the export of energy resources, which has a positive impact on their foreign trade and balance of payments (Ananyeva, 2019; Bakdolotov et al., 2017; Smaliukienė & Monni, 2019). However, these objectives can only be achieved within

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the framework of compliance with mutually beneficial conditions of cooperation in the joint development and operation of oil and gas pipelines, coordinated energy pricing policy, the formation of cartel agreements on energy exports, and development and research of new hydrocarbon deposits in these countries (Dorian, 2006; Dudin et al., 2019).

Active energy cooperation between Central Asian countries and Russia falls within the purview of the Eurasian Economic Union (EAEU). Under the aegis of the EAEU, the project "Concepts of building a common electric power market of the EAEU" was approved on March 10, 2015. It outlines the milestones, goals, and objectives of the energy market, as well as the means of interaction among its participants (Eurasian Economic Union, 2016). Besides building a conventional electric power market under the EAEU, consolidated markets for petroleum, oil products, and natural gas are being formed. Creating a platform for integrating the manufacturing and production facilities of the EAEC member states into a single economic space was the fundamental purpose behind building a common energy market. Based on preliminary estimates by the SKM Market Predictor, the expected efficiency because of the increased use of the network transfer capacity within the EAEU will be13%for the Russian Federation, 28%for the Republic of Kazakhstan, and 19% for the Kyrgyz Republic (Balyberdin, 2016).

The Russian Federation is attempting to revive its role as the leading supplier of Central Asian hydrocarbons to the global market, but primarily to Europe. Along with negotiations with Kazakhstan and Turkmenistan on coordinating the Caspian Coastal pipeline construction, Russia, in liaison with Uzbekistan, is developing a design for the Central Asia-Center-1 and Central Asia-Center-2 gas pipeline systems (ChelPipe Group, 2019). Gas is expected to be transported from Turkmenistan through Uzbek territory to central Russia. However, its prospects, including that of the Caspian Coastal pipeline, remain ambiguous. By contrast, the construction of the Central Asia–China gas pipeline in 2009 allowed Turkmenistan to counter Russia’s monopoly of Turkmen exports. Before 2009, 90% of Turkmen gas exports were transported via the Russian pipeline, and the remaining 10 % were sold to Iran, whereas in 2010, Turkmenistan opened the Dauletabad–Sarakhs–Khangiran pipeline for a nominal supply of 10 billion m^3ofnatural gas to Iran (Indeo, 2018).

The outstanding issue of hydrocarbon transit tariffs is the primary stumbling block in Russia's energy relations with Central Asia. This is because no transit tariff setting or adjustment exists either in the EAEU or the post-Soviet states for an integrated system of gas, oil, and petroleum products. Owing to increasing petroleum transit rates, Kazakhstan imposed a new tariff on Russian oil transit to China. In 2019–2023, this will amount to USD 15 per ton without value-added tax (VAT) (for the JSC KazTransOil pipeline), according to the Orders of the Minister of Energy of the Republic of Kazakhstan for 2019–2023 (KazTransOil, 2019). In 2015–2017, the average tariff was about USD12.5 per ton (without VAT). From January 1, 2018, the tariffs for oil transportation to China along with the territory of Kazakhstan through the Russian side of the pipeline, Priirtyshsk–Atasu, were reduced by 16.7%. Then, on April 1 of the same year, Kazakhstan increased its tariff in the same direction (Atasu–Alashankou) by 2.5 times (Chichkin, 2019). This can be attributed to Kazakhstan's plans to increase its oil deliveries to China, as well as growing competition between Kazakhstan and the Russian Federation for the Chinese oil market.

Moreover, China remains the largest oil importer. Increases in transit tariffs are also evident in the transit of Russian oil through Kazakhstan to Uzbekistan. The cost of Russian oil transit through Kazakhstan to Uzbekistan until December 31, 2017, was approximately USD 23 per ton without VAT (Oil Capital, 2017). However, in January 2018, the tariff was raised to almost USD 26 (Chichkin, 2019). It is not implausible that the tariffs will continue to grow on this route, if only because Kazakhstan has long been interested in increasing its oil deliveries to Uzbekistan (Chichkin, 2019). This may indirectly contribute to arise in Russian oil transit prices. If Russia and Central Asian countries cooperate seamlessly on the pricing of hydrocarbons and their deliveries, it will give them a useful tool to further their long-term interests across Central Asia. Given the context of Russia's weakened position, the purpose of this research is the development of an optimization model for determining transit tariffs for energy resources, ensuring maximum efficiency of cooperation between Russia and the countries of Central Asia. The mutual effectiveness of cooperation between Russia and Central Asia is discussed at length, particularly considering relations that would be the most economically advantageous. The effect of

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hydrocarbon transit tariffs on the efficiency of export-import operations among the countries is identified, and models for determining the optimum transit rates that would be mutually advantageous for partner countries are identified.

The remainder of the study is organized as follows: Section 2 explains the potential for cooperation between Russia and Central Asia in the energy sector. Sections 3, 4, and 5 present the information base and technology for determining the optimal values of gas and oil transit tariffs between Russia and Central Asia. Conclusion summarizes the research and justifies its importance for resolving energy cooperation issues between Russia and Central Asia.

2. Methods and materials

The authors developed an optimization model of gas and oil transit tariffs to increase the efficiency of energy relations between Russia and Central Asia.

The GDP elasticity indicators for each country relative to the total volume of energy exports to Central Asian countries (k_{EEi}) and energy imports (k_{EIi}) were used as indicators of economic effectiveness of energy export–import relations (Elsner et al., 2015):

$$k_{EEi} = \sum \frac{\Delta GDP_{ik}\ (\%)}{\Delta E_{ik}\ (\%)}\ / \ n, \tag{1}$$

$$k_{EIi} = \sum \frac{\Delta GDP_{ik}\ (\%)}{\Delta I_{ik}\ (\%)}\ / \ n, \tag{2}$$

where k_{EEi} is the coefficient of the i^{th} country's GDP elasticity of exports; k_{EIi} is the coefficient of the i^{th} country's GDP elasticity of imports; $\Delta GDP_{ik}(\%)$is the GDP growth rate of the i^{th} country over the k^{th} period, expressed as %;$\Delta E_{ik}(\%)$is the growth rate of total exports of the i^{th} country over the k^{th} period, expressed as %;$\Delta I_{ik}(\%)$ is the growth rate of total imports of the i^{th} country over the k^{th} period, expressed as %; and n is the number of periods.

To reflect the environmental factor in the efficiency of export-import energy operations, indicator ρ_{CO_2} was calculated for each examined country and the coefficient of environmental efficiency k_{Ecij} (Eqs. 3 and 4):

$$\rho_{CO_{2}ij} = \mu_i \times E_{ij}, \tag{3}$$

where $\rho_{CO_{2}ij}$ is the indicator of the total CO_2 emission amount for the i^{th} country in relation to the j^{th} country; μ_i is the specific weight of CO_2emissionper unit of energy production in the i^{th} country; Eij is the value of exports of the i^{th} to the j^{th} country; and the i^{th} country is an exporting country, while the j^{th} country is an importing country.

$$k_{Ecij} = 1/\rho_{CO_{2}ij} \tag{4}$$

where $k_{Ecij}$is the coefficient of environmental efficiency of the i^{th} country's exports to the j^{th} country.

To quantify effectiveness, the integrated index *(I)* was calculated based on the following indicators:

$$I_{ij} = w_{EI} \times k_{EIijk} + w_{EE} \times k_{EEijk} + w_{Ec} \times k_{Ecijk} + \varepsilon, \tag{5}$$

where $w_{EI}$is significance of the coefficient of GDP elasticity of energy imports; k_{EIijk} is a standardized value of the coefficient of the i^{th} country's GDP elasticity of the import of energy resources into the j^{th} country over

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the k^{th} period; $w_{EE}$is the significance of the coefficient of GDP elasticity of energy exports;$k_{EEijk}$is a standardized value of the coefficient of the i^{th} country's GDP elasticity of energy exports for the k^{th} period;$w_{Ec}$is the significance of the environmental performance factor; $k_{Ecijk}$is a standardized value of the environmental performance coefficient of energy exports for the i^{th} country over the k^{th} period; andε is a model error.

It is proposed to build the integral indicator based on the results of factor analysis, where the following indicators are used as factors k_{EIijk}, k_{EEijk}, and k_{Ecijk}. All factors that are used in the model are stimulants: their increase positively characterizes the efficiency of export-import relations, which means that the cumulative effect of these indicators, taking into account the error, is 100%. The indicator that characterizes the influence (informativeness) of each factor in the study of the behavior of the system, and gives a total of 100%, is the indicator of dispersion. Therefore, it is proposed to use the percent of the variance of the corresponding factors as weighting factors when building the integral model. This approach to determining weighting factors is used in the works by (Fernando et al., 2012).

Using various measurement unit values and different dimensions in factor analysis is possible only after standardizing the indicators k_{EIijk}, k_{EEijk}, and k_{Ecijk} as follows (Zhang et al., 2018):

$$k_{sti} = \frac{k_i - \bar{k}_i}{y}, \qquad (6)$$

where k_{sti} is the standardized value of the i^{th} indicator; ki is the calculated value of the i^{th} indicator; $\overline{k}_i$ is the arithmetic mean value of the i^{th} indicator over this period, and y is a standard deviation of the i^{th} indicator.

Next, a gravitational model is developed for determining the factors that affect the efficiency of export-import energy operations (Cantore & Cheng, 2018):

$$Y = a_0 \times X_1^{a_1} \times X_2^{a_2} \times X_3^{a_3}, \qquad (7)$$

where Y is the integral indicator of the export-import energy operations effectiveness of the i^{th} country relative to the j^{th} country; X_1 is the export-import potential of the i^{th} country;$X_2$is the export-import potential of the j^{th} country;$X_3$is the transit tariff for the i^{th} country; and a_0, a_1, a_2, and $a_3$are the elasticity coefficients of the relevant indicators.

Both parts of the equality were prologized, and the function was reduced to the form of a multifactor regression model to solve the function (7):

$$lnY = lna_0 + a_1 lnX_1 + a_2 lnX_2 + a_3 lnX_3 \rightarrow \bar{\bar{Y}} = \bar{\bar{a}}_0 + a_1 \times \bar{\bar{X}}_1 + a_2 \times \bar{\bar{X}}_2 + a_3 \times \bar{\bar{X}}_3, \qquad (8)$$

where $\bar{\bar{Y}}$ is a dependent variable; $\bar{\bar{X}}_1 - \bar{\bar{X}}_3$ are independent variables; $\bar{\bar{a}}_0$ is the constant term; $a_1 - a_3$ are coefficients for independent variables; $\bar{\bar{Y}}$ = lnY; $\bar{\bar{a}}_0$ = lna_0; $\bar{\bar{X}}_1$ = lnX_1; $\bar{\bar{X}}_2$ = lnX_2; $\bar{\bar{X}}_3$ = lnX_3; $a_1 - a_3$ are the elasticity coefficients of the relevant indicators (Eq. 7).

The Statistic determined unknown model parameters ($\bar{\bar{a}}_0, a_1, a_2, a_3$) as they are using the least squares method.

The integral indicator calculation (Eq. 5) is based on the standardized values of indicators, obtained by comparing values for the i^{th} country over the j^{th} period with sample means. Therefore, a positive value of the indicator shows that the effectiveness of export-import operations for the countries examined was above the sample mean. Negative values were indicative of the effectiveness being below the sample mean.

To study the effect of (gas and oil) transit tariffs on the energy trade development in Central Asian countries, two gravity models were developed, which differ in indicator X_3, the type of tariff under study.

3. Data

The economic effectiveness of export-import operations is characterized by their profitability (Doan & Xing, 2018). Therefore, to assess the economic effectiveness of export-import operations, the level of a country's economic development expressed as GDP was used. Regarding the impact of energy trade volumes, the export of any product leads to an increase in GDP, whereas its import leads to economic contraction. At the same time, the opposite effect is possible. In case of energy shortages, the import of energy products stimulates economic development and GDP growth, as evidenced by conventional economic theory as proposed by Smith (2012), Ricardo (2015), and Mill (2012). Therefore, it is expedient to use the indicators of elasticity of each country's GDP concerning the total volume of exports to Central Asia based on the data in Table 3. This allows the study to reflect the effectiveness of export-import relations. Descriptive statistics are given in Tables 1-2. The calculations were made using Eqs. 1 and 2.

High values of the variation coefficients and the lack of stable dynamics (Table 1) indicate the uneven development of energy trade between the countries of Central Asia and in terms of the structure dominated by Russia and Kazakhstan and in dynamics. High variation coefficients (over 20%) also necessitate the standardization of data when building models to ensure sample uniformity.

Table 1. Descriptive statistics of data on energy trade between the countries of Central Asia

Country	Average exports to Central Asia, USD 1,000,000								Variation coefficient for the period, %
	2010	2011	2012	2013	2014	2015	2016	2017	
Russian Federation	52659	70355	74853	75670	58297	36435	22780	35760	37.52
Kazakhstan	8341	12789	13184	13207	10382	5436	3836	5285	42.77
Uzbekistan	389	426	274	448	278	154	158	152	43.70
Turkmenistan	464	1699	2644	2730	1907	1538	1174	1209	45.57
Kyrgyzstan	33.84	55.98	46.92	38.90	25.90	16.65	17.72	37.00	40.17
Tajikistan	0.17	0.03	0.20	0.04	8.20	8.83	8.72	8.62	104.28
Country	Average imports to Central Asia, USD 1,000,000								Variation coefficient for the period, %
	2010	2011	2012	2013	2014	2015	2016	2017	
Russian Federation	1.09	4.88	183.27	189.16	209.30	224.50	73.57	110.01	72.60
Kazakhstan	436.92	927.10	916.78	1037.30	401.56	292.88	283.55	326.94	55.87
Uzbekistan	196.97	176.99	214.52	257.47	136.85	103.73	87.16	131.27	35.81
Turkmenistan	0.94	1.37	1.70	1.99	1.52	1.04	1.23	1.27	25.15
Kyrgyzstan	168.33	189.54	229.79	252.10	228.93	152.01	77.52	124.32	33.37
Tajikistan	-	-	-	-	150.05	109.59	93.04	93.75	-

Source: Trade Map, 2019

An even more significant variation in the GDP growth rate in Central Asia (Table 2) is over 100%. Against the background of this indicator, the variation of the CO_2 emission concentration indicator is less significant - does not exceed 25%.

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Table 2. Descriptive statistics for gross domestic product growth and indicator value of the share of CO_2 emissions per unit of energy production in Central Asia

Country	Gross domestic product growth		Indicator value of the share of CO_2 emissions per unit of energy production	
	Average value	Variation coefficient, %	Average value	Variation coefficient, %
Russian Federation	4.30	478.54	0.47	3.86
Kazakhstan	5.96	342.44	0.57	9.51
Uzbekistan	5.77	249.63	0.61	22.34
Turkmenistan	9.01	154.60	0.20	0
Kyrgyzstan	6.68	170.98	0.20	0
Tajikistan	5.29	231.78	0.20	0

Source: Knoema, 2019; Global Energy Statistical Yearbook, 2018

The production of hydrocarbons and their processing cause CO_2 emissions to increase in the atmosphere. Based on the official statistics on CO_2 emissions, hydrocarbon production is an integral factor for air pollution intensity due to the extraction and processing of energy resources. A pollution indicator is the specific weight of CO_2emission per unit of energy production. To describe the environmental component of international trade in energy resources, the indicator c_{CO_2}(Eq.3) was calculated for each country. This is an indicator ofCO_2emission amount in proportion to a country's exports to all the other countries in the study group on a standalone basis (in USD) (Global Energy Statistical Yearbook, 2018). When assessing the effectiveness of import operations, the environmental factor was not included, as import does not lead to environmental pollution. Based on the indicator of the total CO_2 emission amount, the coefficient of environmental efficiency (k_{Ecij}) is calculated. It is the inverse of the CO_2 emission indicator (Eq.4) based on the data for 2010–2017.

For the integral assessment effectiveness of energy export and import operations, the following indicators were used: the coefficient of GDP elasticity of energy exports (as %), the coefficient of GDP elasticity of energy imports (as %), and the environmental performance indicator. These figures were calculated for Kazakhstan, Kyrgyzstan, Russia, Tajikistan, Turkmenistan, and Uzbekistan on a standalone basis for 2010–2017 (Eq. 5). Weighting factors (w) were determined through factor analysis using Statistica and correspond to indicator variance percentage values.

During the factor analysis, criteria for determining the optimum quantity of factors were not used, since the purpose of factor analysis in this study was not to reduce data but to determine the significance of all the indicators. Factor analysis based on data for 2010–2017 indicates that the 1st factor corresponds to the coefficient of GDP elasticity of energy exports, the 2nd factor to the coefficient of GDP elasticity of energy imports, and the 3rd factor to the coefficient of environmental efficiency of energy exports. The variance by factors (indicators) is distributed as follows: the dispersion percentage of the 1st factor is 54.8%, the 2nd factor is 32.4%, and the 3rd factor is 9.5%. The cumulative variance percent is 96.7%. The influence of factors unaccounted for in the model is 3.3%. The value of cumulative variance percent exceeds the level of significance 80% (Menke, 2018), which indicates the completeness of factorization and significance of factor analysis.

A gravity model was used (Eq.7) to determine the efficiency factors of export-import energy operations. The gravity model is used because it is a specialized model for evaluating the effectiveness of trade between two countries that are trading partners (Shumilov, 2017; Cantore & Cheng, 2018; Kabir et al., 2017). In this study, when evaluating the effectiveness of trade (gravity) between a pair of countries, indicators of their export and import energy potential (total energy exports and imports of the first and the second country) were used as mass indexes. This approach most accurately reflects the weight of countries in international trade when compared with GDP and other indicators mentioned above (Shumilov, 2017). The physical value of the distance was not used as a "distance." (Baier et al., 2017; Van Bergeijk, 2010; Bergstrand, 1985), since the studied countries are countries of the same region with approximately the same distance between them. The study used the "economic

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distance" - the tariff for the transit of hydrocarbons. It is transit tariffs, as determined in the study, that is the main limiting factor for the development of energy trade between the countries of Central Asia in modern conditions. The integral indicator of the export-import energy operations effectiveness calculated by Eq. (5) was used as a dependent variable, as opposed to the foreign trade volumes, as in the classical economic gravity model. This can effectively help determine the indicators that affect qualitative indicators of energy trade rather than quantitative ones—that is, the values of the elasticity coefficients of these indicators.

Consequently, an array of data for constructing gravity models was formed: 1) the integral indicator values for the effectiveness of export-import energy operations between the i^{th} and j^{th} Central Asian countries over 2010–2017, calculated according to the methodology proposed in the article (Y); 2) standardized values of the sum of total exports and imports of mineral fuels, mineral oils, and their distillation products in the i^{th} country over the period of 2010–2017 (X_1); 3) standardized values of the sum of total exports and imports of mineral fuels, mineral oils, and their distillation products in the j^{th} country (X_2); 4) standardized values of the gas transit tariff for applied by Russia (X_3'); 5) and the oil transit tariffs (X_3''). The standardized values of these indicators were used by applying Eq. (3).

For the model of the dependence of the efficiency of export-import relations on gas tariffs, an array of data formed for each country of pairs: Russia–Kazakhstan, Russia–Uzbekistan, Russia–Turkmenistan, Russia–Kyrgyzstan, Russia–Tajikistan, Kazakhstan–Uzbekistan, Kazakhstan–Turkmenistan, Kazakhstan–Kyrgyzstan, Kazakhstan–Tajikistan, Kyrgyzstan–Tajikistan. For the model of dependence of efficiency of export-import relations on oil tariffs - this is each country of the pairs: Russia–Kazakhstan, Russia–Uzbekistan, Russia–Turkmenistan, Russia–Kyrgyzstan, Russia–Tajikistan, Kazakhstan–Uzbekistan, Kazakhstan–Turkmenistan, Kazakhstan–Kyrgyzstan, Kazakhstan–Tajikistan. Since these indicators were logarithmized when building a gravity model, observations with negative values were discarded.

The gas transit tariffs approved by the Federal Antimonopoly Service of the Russian Federation (2019) were taken as indicator X_3, as well as the tariffs applied by Kazakhstan (KazTransOil, 2019; Chichkin, 2019; Mazorenko, 2014) and Kyrgyzstan (EurAsiaDaily, 2018) for Central Asia. Thus, tariff modifications are established depending on the gas pipeline type, the availability of a cooperation agreement, and possible preferential terms or sanctions (TASS Russian Information Agency, 2017).

Oil transit tariffs are even more differentiated by the Federal Antimonopoly Service of the Russian Federation (2019). Commercial institutions and departments of Kazakhstan have not defined unified tariffs (Oil Capital, 2017; Neftegaz, 2017; Mazorenko, 2014; But, 2019). Therefore, in this research, tariffs for oil transit through the trunk pipelines of Transneft PJSC, which has monopoly control over the oil transit, are taken as an indicator ($X_3^{''}$) for Russia (Transneft, 2019). The Federal Antimonopoly Service approves any decision-making regarding changes in the Transneft tariffs. The tariff for oil supplies to refineries of the Russian Federation and EAEU member states was taken for analysis from the variation of tariffs. For Kazakhstan and Kyrgyzstan, the averaged indicators of tariff values relative to Central Asian countries were taken (Trade Map, 2019; Transneft, 2019; KazTransOil, 2019; Chichkin, 2019; Mazorenko, 2014; Oil Capital, 2017; Neftegaz, 2017; EurAsiaDaily, 2018).

4. Results

Table 3 shows the arithmetic mean values of the elasticities of GDP from imports and exports by the country for the study period. The average values can be calculated because the coefficient of variation of the calculated elasticity coefficient within one country does not exceed 5%, and the coefficients themselves demonstrate the same nature of influence throughout the entire period: either direct or reverse. Thus, the sample is homogenous and qualifies for statistical processing.

The values of elasticity coefficients indicate that GDP is elastic concerning the volume of foreign trade in energy resources (the elasticity coefficient exceeds 1) for Russia, Kazakhstan, and Turkmenistan. Therefore, the development of energy cooperation based on an increase in foreign trade in mineral fuels, mineral oils, and their

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distillation products by 1% will lead to an increase in the GDP of Kazakhstan by 2.93%, that of Russia by 1.47%, and that of Turkmenistan by 1.16% (Table 3). Thus, Kazakhstan is most interested in developing energy cooperation, particularly in increasing hydrocarbon exports, as, among other Central Asian countries, its GDP is most elastic to exports (+10.29).

For other countries, the GDP is less elastic, which is due to smaller volumes of international energy trade within Central Asia. Importantly, both exports and imports of energy resources within Central Asia have a positive impact on the development of the economy for the Russian Federation only. This is determined by the significant hydrocarbon reserves in the country, as well as its sufficiently developed industry and efficient energy policy.

Table 3. Values of GDP elasticity coefficients concerning the volumes of export and import of energy resources

Country	Values of GDP elasticity coefficients (%)		
	Relative to energy exports	Relative to energy imports	Relative to the volume of foreign trade in energy resources
Kazakhstan	+10.29	-0.06	2.93
Kyrgyzstan	-0.39	+0.55	0.52
Russia	+1.35	+0.07	1.47
Tajikistan	-1.89	-1.09	-0.90
Turkmenistan	+1.13	-0.26	1.16
Uzbekistan	+0.64	-0.44	-0.08

Based on the calculations, it is advisable for Kazakhstan, Kyrgyzstan, Russia, and Turkmenistan to increase the volumes of foreign trade in energy resources at the existing resource consumption level. For Tajikistan and Uzbekistan, an increase in trade should be accompanied by more profitable production and more efficient use of hydrocarbons.

For Russia, the GDP elasticity coefficients relative to imports and exports presented in Table 3 are positive. Therefore, any foreign trade energy operations with Central Asian countries would be profitable. Besides, the greater the foreign trade turnover, the higher the effectiveness. Only the environmental factor harms effectiveness: For Russia, the share of CO_2 emissions is 0.481 kCO_2/USD (Global Energy Statistical Yearbook, 2018), which is one of the highest indicators among Central Asian countries (after Kazakhstan, with 0.509). However, the significance of the environmental factor is not decisive because the degree of its influence is 9.5% (Eq. 2). On the contrary, for Tajikistan, both exports and imports adversely affect GDP. With any export-import ratio, the integral indicator of energy trade is negative for Tajikistan.

Based on the indicators of efficiency of export-import relations and the model of the integral efficiency indicator (Eq. 5), and considering the weighting factors, the model for calculating an integrated index of the effectiveness of export-import energy operations for Central Asian countries and Russia was developed:

$$I_{ij} = 0.324 \times k_{EIijk} + 0.548 \times k_{EEijk} + 0.095 \times k_{Ecijk} + e, \quad (9)$$

Table 4 reflects the values of the integral indicators of mutual trade efficiency among the countries of Central Asia for 2017, calculated using Eq. 9. The calculation of the integral indicator is based on the values of the weighting factors determined using factor analysis. Therefore, the indicators of the adequacy of the obtained integral estimates are the statistical characteristics of the factor analysis—that is, the cumulative percentage of dispersion, which is 96.7%. The actual excess value of the cumulative percentage variance (96.7%) over the allowable 80% limit (Menke, 2018) indicates the completeness of factorization and the importance of factor analysis. Hence, the integrated assessment results of the effectiveness of mutual trade between Central Asia and Russia are adequate.

Based on the calculations (Table 4), export-import relations are most mutually beneficial for Russia–Kazakhstan, Russia–Kyrgyzstan, and Kazakhstan–Kyrgyzstan. However, export-import relations are

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economically inefficient for Uzbekistan–Kyrgyzstan, and Kyrgyzstan–Tajikistan. The Central Asian countries that do not carry out mutual trade in mineral fuels, mineral oils, and their distillation products are Uzbekistan–Turkmenistan (during 2010–2017) and Turkmenistan–Kyrgyzstan (in 2017). Therefore, for these pairs of countries, the integral indicator of export-import energy operations effectiveness was not calculated, and the gravity model was not constructed. For countries that do not export energy resources within the considered trading partners, k_{EEijk} = 0 and k_{Ecijk} = 0 (Eq. 9). For countries that do not import energy resources within the considered trading partners, k_{EIijk} = 0. The values of the integral effectiveness indicator of export-import energy transactions among Central Asian countries were calculated similarly for 2010–2016.

The constructed gravity models (Eqs. 4 and 5) indicate that the effectiveness of export-import relations for the country trading in mineral fuels, mineral oils, and their distillates mostly depends on its export-import potential. That is, the elasticity coefficient amounts to 1.01–1.06 regardless of the tariff type (gas or oil transit tariff). Thus, with the increase in the country's export potential by 1%, the effectiveness of export-import relations increases by 1.01–1.06 %. The elasticity of effectiveness relative to the export-import potential of a partner country is 0.62–0.69, which is indicative of lesser influence exerted by this factor (Table 4). Eqs. 4 and 5 confirm the hypothesis of the mutual negative impact of transit tariffs on the effectiveness of export-import relations—the elasticity coefficient is negative (-0.94 and -0.87). Thus, a conclusion can be drawn regarding the expediency of reducing transit tariffs in the modern conditions of foreign trade.

Table 4. Values of the integral indicator of the effectiveness of export–import energy relations between Central Asian countries and Russia for 2017

Trading partners of export–import energy relations	For the 1st trading partner	For the 2nd trading partner
Russia–Kazakhstan	+1.29	+0.71
Russia–Uzbekistan	+1.11	-0.83
Russia–Turkmenistan	+0.62	-0.44
Russia–Kyrgyzstan	+1.16	+0.25
Russia–Tajikistan	+0.9	-1.11
Kazakhstan–Uzbekistan	+0.57	-0.07
Kazakhstan–Turkmenistan	-0.67	+0.85
Kazakhstan–Kyrgyzstan	+0.32	+0.05
Kazakhstan–Tajikistan	+0.66	-1.04
Uzbekistan–Turkmenistan	-	-
Uzbekistan–Kyrgyzstan	-0.25	-0.13
Uzbekistan–Tajikistan	+0.19	-0.21
Turkmenistan–Kyrgyzstan	-	-
Turkmenistan–Tajikistan	+1.15	-0.67
Kyrgyzstan–Tajikistan	-0.18	-0.42

Next, the gravity model of the efficiency of export-import energy operations (Eq. 7) models for determining the effectiveness of export-import energy operations among the countries is used. Thus, reflecting the export-import potential of the countries involved in trade relations and economic barriers to the development of relations, the gas transit tariff (Eq. 10) and the oil transit tariff (Eq. 11) were developed:

$$Y = 4.35 \times X_1^{1.01} \times X_2^{0.62} \times X'{}_3^{-0.87}, \quad (10)$$

$$Y = 2.61 \times X_1^{1.06} \times X_2^{0.69} \times X''{}_3^{-0.94}, \quad (11)$$

To assess the statistical significance of the constructed models (10) - (11), the Fisher and Student criteria were calculated (Table 5).

Table 5. Indicators of the statistical significance of models for determining the effective tariffs for the transit of gas and oil between Central Asian countries and Russia

Model for determining effective gas transit tariffs			Model for determining effective tariffs for oil transit		
Significance indicator	Value		Significance indicator	Value	
Fisher's F-test	Calculated 36.24; Tabular 2.73		Fisher's F-test	Calculated 29.47; Tabular 2.76	
Student's t-test	Calculated:		Student's t-test	Calculated:	
	For the constant term	3.47		For the constant term	3.01
	For X_1	3.06		For X_1	2.94
	For X_2	2.88		For X_2	2.35
	For X_3’	-2.97		For X_3’’	-2.76
	Tabular 1.992			Tabular 2.001	

The statistical significance of the constructed gravity models is indicated by:
1) Sample sufficiency (63 / 79 observations): Indicators of mutual trade between Russia and Central Asian countries over eight years.
2) Sample homogeneity: Because of the standardization of indicators, the variation coefficient for each country did not exceed 10%;
3) The value of the determination coefficient, which amounts to 0.81 for Eq.9 and 0.78 for Eq. 10: The values of the determination coefficients show that the effectiveness of export-import energy operations among countries depends on the indicators included in the equations by 78–81%, with an acceptable level being not less than 74%;
4) Significant Student and Fisher tests (Table 5), for which the calculated values exceed the table in absolute value at a significance level of 95%.
To determine the optimal value of the gas and oil transit tariff, ensuring the maximum effectiveness of trade in energy resources between the countries of Central Asia, an optimization equation (12) was solved, in which the indicator X_3 is a controllable factor:

$$\begin{cases} Y = 4.35 \times X_1^{1.01} \times X_2^{0.62} \times X_3'^{-0.87} \rightarrow max \\ Y = 2.61 \times X_1^{1.06} \times X_2^{0.69} \times X''^{-0.94}_3 \rightarrow max' \end{cases} \qquad (12)$$

where Y is the standardized value of the integral indicator of export-import relations effectiveness for the country; X_1 is the standardized value of the export-import potential indicator for the country under study; X_2 is the standardized value of the export-import potential indicator for the partner country; $X'_3$is the standardized value of the gas transit tariff; and X''_3 is the standardized value of the oil transit tariff.

The optimal tariffs are calculated for oil and gas transit across the territory of Russia, Kazakhstan, and Kyrgyzstan. These tariffs ensure maximum effectiveness of cooperation between the countries of Central Asia—that is, the maximum value of effectiveness indicators (Eq. 12) for both countries. In this case, the resulting indicator of trade effectiveness, calculated by Eq.10, is determined for the i^{th} and the j^{th} country, after which the summarizing indicator is calculated as their product. The summarizing indicator of trade effectiveness calculated in this way reflects the interests of the exporting and importing country. The effectiveness of determining an optimal tariff for oil transit (Eq.11) is calculated similarly.

The values obtained from the application of the optimization equation (Eq. 12) are presented in Table 6.

Russia and Kazakhstan mainly provide oil and gas transit for all Central Asian countries, while Kyrgyzstan provides gas transit. Therefore, under the study’s framework, the calculated optimal tariffs within the framework of the energy cooperation development are given in Table 6. Based on these data, it can be affirmed that the gas

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transit price for Russia should be reduced in Central Asian countries and it should make, on average, USD 0.84 per 100 km to increase the effectiveness of energy cooperation. That is, the current tariff should be reduced by USD 1.06. In turn, Russia should also reduce tariffs for the transit of Kazakh gas by USD 0.6, down to USD 0.82 per 100 km. For Kyrgyzstan, Russia should lower the level of the gas transit tariff by USD 2.61 down to 0.89 per 100 km (Table 6).

Table 6. Optimal values of the equilibrium tariffs for oil and gas transit in the framework developing energy cooperation between Russia and Central Asian countries

Transit country	Partner country					
	Russia	Kazakhstan	Kyrgyzstan	Tajikistan	Turkmenistan	Uzbekistan
Gas transit (USD/1000 m^3/100 km)						
Russia	-	0.82	0.89	0.9	0.82	0.79
Kazakhstan	0.82	-	0.9	0.9	1.2	1.0
Kyrgyzstan	0.89	0.9	-	1.8	2.1	2.1
Oil transit (USD/ton)						
Russia	-	12.5	11.1	11.8	11.5	12
Kazakhstan	12.5	-	10.2	10.5	11	11.1

5. Discussion

The justification of mutually beneficial energy cooperation in the context of expanding export-import operations with hydrocarbons for Russia and the majority of Central Asian countries using the elasticity coefficient was one of the most important scientific results of this research. These findings negate the dominant scholarly position regarding the desire of the Russian Federation to maintain monopoly control over energy resources of Asian countries (Maness & Valeriano, 2015; Öğütçü & Ma, 2019). The substantiation of the positive effect of building the potential of export-import relations between Russia and Central Asian countries as an economic factor is a significant result herein. It is expected to contribute to an increase in the growth rates of national economies.

The developed model for calculating the optimal transit tariffs for energy resources between Russia and the countries of Central Asia testified to the need for mutual reduction of their levels. Reciprocal reduction in transit tariffs for hydrocarbons on the part of Russia and the partner countries from Central Asia should be the main factor in achieving current economic goals. Based on the optimization results, the current tariff for the transit of Russian oil through Central Asian countries amounts to USD 21.4 per ton of oil, whereas, according to our calculations, the optimal tariff level (average for Central Asia) for Russia should be USD 11.72, which is 45%lower. In turn, it is advisable for Russia to reduce the tariff for Kazakh oil by another USD 2.5, resulting in USD 15 per ton of transit. Reducing transit tariffs among partner countries will contribute to expanding energy cooperation between Russia and Central Asian countries. Based on the gravity models developed (Eqs.10 and 11) and the data in Table 4, a decrease in the gas transit tariff by 1% will lead to an increase in the effectiveness of export-import relations by 0.87%.

Further, a decrease in the oil transit tariff by 1% will result in increased effectiveness of export-import relations by 0.94%, which will be conditioned by GDP growth. Russia does not have the same opportunity as China does to build bilateral relations with Central Asian countries. Thus, it is challenging to offer large-scale investments, massive infrastructure, and transport projects that can provide the region with an opportunity to implement its transit potential and participate in international trade routes. This has been emphasized in research before (Mohapatra, 2015; Pepe, 2017).

Further, this study's methodological approach determines the optimal level of transit tariffs for hydrocarbons between Russia and Central Asia, which can enable healthy partnership and competition. This would maximize the economic benefits of trading countries, with the potential to increase the export-import benefits in energy cooperation.

Thus, maintaining the stability of the conditions for mutually beneficial energy cooperation between Russia and Central Asia under current conditions is possible by forming an equivalent tariff net for the transit of primary hydrocarbons such as crude oil and natural gas. Unlike other modern studies that have focused on political factors affecting transit tariffs (Doan & Xing, 2018; Kazantsev, 2016; Aminjonov, 2017; Zhang et al., 2018), this research suggests compliance with the equivalence principle in the proposed approach. That is, the establishment of the same transit costs between country-trading partners is a prerequisite for the development of equal relations between Russia and the countries of Central Asia. This would also enable the conditions of financial benefits or the mutual adjustment of various levels of transit tariffs to be compared in the event of a change in external conditions.

It seems unconditional that today, despite ample motive, Russia is unable to exercise control over energy resources in Central Asia. Therefore, it should pursue a policy of seeking balance with key players. If the logic of the Russian leadership were to be followed, interaction with China seems more preferable than with the United States. Therefore, Russia and China will have to find a mechanism for coordinating interests in the economic sphere to prove that any strategic partnership goes beyond declarative intent.

It should be noted that this study focused on a narrow range of problems regarding the optimization of oil and gas transit tariffs between Russia and Central Asia. However, more opportunities for energy cooperation exist, such as the development of a joint oilfield services market, the creation of financial-industrial groups, and the creation of joint industrial enterprises for the production and transit of energy resources. These issues are yet to be evaluated in terms of economic efficiency. In the authors' opinion, these aspects deserve a separate study, since, along with the scientific results obtained, they will contribute to improving the efficiency of energy cooperation between Russia and Central Asia.

Conclusion

This study developed a model of optimization of transit tariffs for energy relations between Russia and Central Asia within the context of increasing competition. When implementing export–import energy cooperation under existing conditions, trade is most efficient for Russia–Kazakhstan. High effectiveness is conditioned on countries having significant volumes of exports and imports, and their positive impact on the GDP of these countries. The values of elasticity coefficients confirm this. Trade relations are mutually beneficial for Russia–Kyrgyzstan, and Kazakhstan–Kyrgyzstan. However, the established trade relations are economically disadvantageous for Uzbekistan–Kyrgyzstan, and Kyrgyzstan–Tajikistan.

The effectiveness of export-import relations for Russia in the Central Asian energy sector depends to the greatest extent on its export-import potential. The increase in the export potential of one of the countries by 1% results in an increase in the effectiveness of export-import relations by 1.01–1.06% for this country. This confirms the hypothesis of the mutual negative impact of transit tariffs on the effectiveness of export-import relations.

The developed models for calculating optimization transit tariffs for hydrocarbons between Russia and Central Asia are based on the mutual reduction of tariff values and the principle of equivalence. The obtained results are of practical importance as they account for the mutual economic benefits of Russia and Central Asia. They help develop the principles of equivalence and partnership in cooperation. The basis for fruitful cooperation with major competing countries is also further developed.

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