Determinants of the Russia and Asia–Pacific energy trade

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ABSTRACT

Asia remained the largest energy consumer in 2020. The Russian Federation hopes to gain a greater share of the Asian energy market. This study examined the Russian Federation–Asia and Pacific energy trade patterns using gravity trade theory and GMM panel estimation for 17 selected Asia and Pacific economies. We found that the Russian Federation's energy exports to the Asia–Pacific region (APR) followed the Linder hypothesis, and economic growth positively influenced Russian energy exports in the region. Furthermore, The results indicated that the sanctions against Russia since 2014 stimulated an increase in Russian energy exports to the APR. To improve the region's energy security, we recommend developing an energy trading hub in the APR to increase regional pricing power.

1. Introduction

Asia's determination and economic successes have significantly increased its energy demands. According to the BP Statistical Energy Review [1]; the Asia–Pacific region (APR) remained the world's largest market for energy resources, accounting for 43.17% of the global demand in 2018. The largest consumer continues to be the People's Republic of China (PRC) (3273.5 million tons of oil equivalent), distantly followed by India (809.2 million tons of oil equivalent) and Japan (454.1 million tons of oil equivalent). Fig. 1 shows the consumption trends of top energy consumers in the APR (2008–2018) and top energy importers [2] in the APR (2008–2018). The PRC (as a giant energy consumer), India, Japan, the Republic of Korea, and Indonesia are the APR region's largest energy consumers (see Fig. 2).

Russian Federation energy export volumes to the APR increased from US$1431 million in 2001 to nearly US$73 billion in 2018, as evidenced by the Harmonized System (HS) Code 27 energy exports (mineral fuels, mineral oils, and products of their distillation; bituminous substances; mineral waxes) from Russia to these APR countries: the PRC, the Republic of Korea, Japan, Singapore, Taiwan, India, Malaysia, the

Philippines, Vietnam, Hong Kong (China), Indonesia, Pakistan, Bangladesh, Democratic People's Republic of Korea, Myanmar, Sri Lanka, Cambodia, Nepal, the Maldives, Timor-Leste. Although it delivers less energy to the APR than Europe (Russian energy export volumes to the European Union were approximately US$352 billion in 2018), Russia intends to develop its eastern energy projects to provide a more significant share of the APR's energy imports. For example, according to Russia's long-run 2030 strategy, its gas industry will focus on the East, with export volumes of nearly 75 billion cubic meters by 2030 [3]. To this end, Russia is trying to expand its eastern liquefied natural gas (LNG) fields to cover its potential exports to Asia, the Pacific, and the rest of the world. Henderson and Stern [4] identified the Yamal LNG and Sakhalin-3 projects as Russia's most important energy exports to the APR.

Numerous studies (e.g., Refs. [5–9] have considered Russian Federation energy exports to Asia Pacific nations. This study's major contributions to the existing literature are as follows:

First, we have addressed and modeled the trade pattern characteristics of energy between a major energy exporter (Russia) and a panel of 17 energy importers in the APR: the PRC, the Republic of Korea, Japan,

Singapore, Taiwan, India, Malaysia, the Philippines, Vietnam, Hong Kong (China), Indonesia, Pakistan, Bangladesh, Myanmar, Sri Lanka, Cambodia, and Nepal.

Second, our empirical model is based on a theoretical background from the perspective of consumers' utility function and maximization.

Third, our consideration of the economic sanctions imposed against Russia since 2014 made our empirical findings more straightforward and reliable.

This study employed an advanced econometric estimation methodology under gravity theory trade construction based on the dependent variable of supplies of mineral fuels, mineral oils and their distillation products, bituminous substances, and mineral waxes as energy carriers from 2010 to 2017. At the beginning of 2010, Russia was supplying LNG only to China, India, South Korea, Japan, and Taiwan. In 2018, Thailand and Pakistan joined the list. However, the infrastructure for the supply of different types of energy resources differs widely in terms of the amounts invested (e.g., receiving terminals for oil and LNG). Thus, our model assumes the preservation of the existing trade structure rather than developing a prospective trade balance of energy resources.

The remainder of this paper is organized as follows. Section 2 provides a brief review of the literature. Section 3 describes the study's theoretical background. Section 4 discusses the data and empirical model specification. Section 5 presents our empirical analysis. Section 6 concludes the paper and offers policy recommendations.

2. Literature review

Numerous earlier studies have investigated and analyzed trade pattern modeling using econometric instruments. Pomery [10] argued that uncertainty in trade models is contingent on the extent of markets and market institutions. Nishimura and Shimomura [11] investigated the relationship between trade and indeterminacy in a dynamic general equilibrium model, noting that the long-run Heckscher–Ohlin prediction is vulnerable to the introduction of externality. Yeaple [12] used a general equilibrium trade model to identify the linkages between firm heterogeneity, international trade, and wages. He discovered that in equilibrium, the interaction between the characteristics of competing technologies, international trade costs, and the availability of workers with heterogeneous skills gives rise to firm heterogeneity. Martin-Moreno et al. [13] used a dynamic stochastic general equilibrium (DSGE) model for Spain to analyze real business cycles with tradable and nontradable goods, finding that the cyclical properties of inflation for nontradable and tradable goods were replicated. Viorica [14] sought to model the foreign trade efficiency of EU members by using stochastic frontier analysis in a gravity equation and discovered

that the economic crisis did not significantly alter trade patterns and hierarchies among EU countries; it merely reduced trade performance. Jong et al. [15] proposed a new model for trade flows in Europe using logsum variables. Their trade modeling was based on gravity theory and country-specific random effects, and they confirmed that the new model could fit more effectively with EU trade patterns. Van Ha et al. [16] built a better trade model, identifying significant shifts in export markets, agricultural output, and prices in Vietnam's economy. Taghizadeh-Hesary et al. [17] applied the weighted two-stage least squares estimation method to 21 countries with business relations between Q1 2000 and Q4 2015, among which five were oil exporters (Iran, Russia, the UAE, Indonesia, and Kazakhstan) and 16 were oil importers. Their empirical results revealed that all oil importers face a negative supply shock during an oil price hike. Furthermore, the indirect effect coefficient almost received through trade for all these countries was positive.

Another topic that has drawn considerable attention from previous researchers pertains to energy trade flows among nations. Cabalu and Manuhutu [18] examined the relative vulnerability of eight gas-importing countries in Asia in 2006 using principal component analysis (PCA) for four market risk indicators. They found significant differences in the values of individual and overall indicators of gas vulnerability among the countries. Wood [19] reviewed the global LNG trade in two major regions of Asia and Europe and described the complexity of its commercial, political, and technical drivers. Tong, Zheng, and Fang [20] analyzed the establishment of a natural gas trading hub in the PRC and concluded Shanghai's location was more advantageous than countries such as Malaysia, Japan, and Singapore because of the PRC's supporting policies and highly improved infrastructure in the natural gas sector, along with its initiation of spot and futures markets, and rapid growth of gas production in the country. Chen et al. [21] focused on the competition patterns of global LNG trade by showing networks developed between 2005 and 2014. They found that some European countries (notably, Spain and Belgium) re-exported their LNG because of the reduced demand caused by their weak economies. Moreover, shale gas from the US did not significantly affect the LNG export trade pattern. Kim [22] analyzed changes in the Northeast Asian energy landscape based on the decline in global oil prices, concluding that Russia would seek to keep US LNG in check through price negotiations, and the evolution of an Asian gas hub would be influenced by Russia's and the PRC's reconsidered energy strategies. Holzer et al. [23] investigated the potential effects of the LNG trade shift on the transfer of ships' ballast water and biota. They estimated changes in the associated flux of ships' ballast water to the US during 2015–2040 using existing scenarios for projected exports of domestic LNG. Their
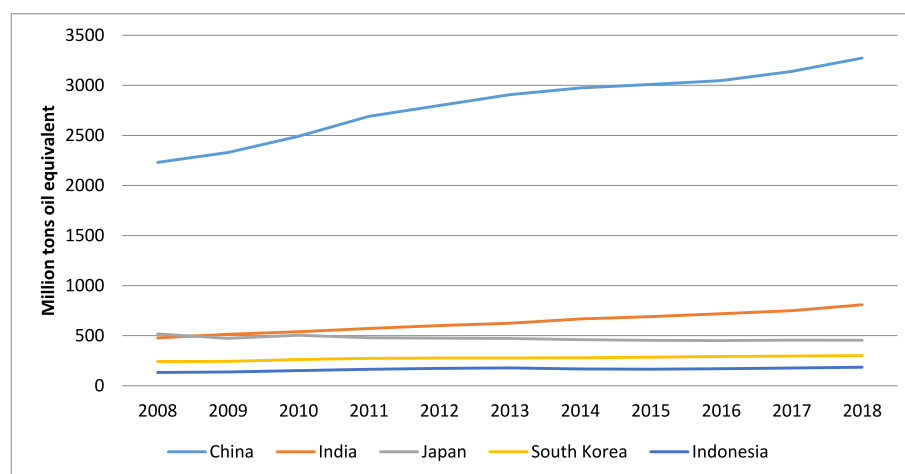

Fig. 1. Top Asia and the Pacific energy consumers, 2008–2018.
Source: Authors' compilation from BP Statistical Energy Review [1].

results predicted an approximately 90-fold annual increase in LNG-related ballast water discharge to the US by 2040 (42 million m^3). Zhang et al. [24] investigated the driving factors of global LNG trade flows by applying the gravity model to 2004–2015 flows. They discovered that pipeline natural gas had a significant substitute effect on LNG trade in the global model. Furthermore, LNG trade in Asia was more sensitive to import prices and R&D investment than in the global model. Varahrami and Haghighat [25] analyzed the effects of LNG products in the Organisation for Economic Co-operation and Development (OECD) countries using the dynamic panel method for seasonal data from 2011 to 2015. The estimation results showed that LNG demands in the selected importing countries were relatively reversible in the short and long term.

Overall, our review of the existing literature found no prior studies have sought to model Russia–APR energy trade flows. We believe our study is the first to consider this topic and model the Russia–APR energy trade pattern using a panel-GMM-gravity trade model.

3. Theoretical background

This section's theoretical background supports the empirical variables and models described in Section 4.

Letcher [26] reported that energy is mainly used for electricity generation. In many Asian nations such as Malaysia and the PRC, the electricity sector is the major consumer of fossil energy resources [27–29].

For this section, to simplify the theoretical framework, we assumed that energy is consumed only in two main sectors and generated only by fossil fuel energy resources. This assumption means that the demand for energy resources comes from two groups: the industry and residential sectors (households). Previous studies have also made this assumption (e.g., Refs. [30,31].

3.1. Industry's energy demand

Equation (1) shows the production function of industry, following Taghizadeh-Hesary and Rasoulinezhad [31] assumed to be in the form of Cobb–Douglas:

$$Y_t^I = F\left(K_t, L_t, E_t^I\right) = K_t^\alpha L_t^\beta \left(E_t^I\right)^{(1-\alpha-\beta)} \tag{1}$$

where Y^I is the total output of industry, K is the capital input, L is the labor input, and E^I is the energy input of industry. We assume a constant

return to scale. In Equation (1), α is the elasticity of production of capital, β is the elasticity of the production of labor, and the elasticity of the production of energy resources is equal to $1 - \alpha - \beta$.

Firms in this industry seek to maximize profits, as shown in Equation (2).

$$Max\pi_t = P_t^Y Y_t^I - r_t K_t - w_t L_t - e_t \left(P_t^E + T_t\right) E_t^I \tag{2}$$

where π is the sector's profit, P^Y is the price of the final products of industry, r is the interest rate, w is the wage rate, e is the exchange rate, P^E is the electricity tariff depending on fossil fuel prices, and T is the transportation costs, which is a function of the distance between the energy exporter and importer.

Equation (3) shows the first-order condition of profit with respect to E^I:

$$\frac{\partial \pi_t}{\partial E_t^I} = (1 - \alpha - \beta) \frac{P_t^Y Y_t^I}{E_t^I} - e_t \left(P_t^E + T_t\right) = 0 \tag{3}$$

Energy demand is represented in Equation (4):

$$E_t^I = (1 - \alpha - \beta) \frac{P_t^Y Y_t^I}{e_t \left(P_t^E + T_t\right)} \tag{4}$$

As shown, the industry's energy demand is a function of the elasticity of the production of labor and capital, the real output of the industry sector, the electricity tariff (the price of fossil fuels), the exchange rate, and the transportation cost, which is a function of the distance between the supplier and the consumer. This model is in line with the gravity trade theory in which the trade flows between two economies directly depend on the economy's size and indirectly depend on the geographical distance between them.

3.2. Residential energy demand

Equation (5) shows the utility function of households based on the Stone–Geary utility function, also known as "founded for essential commodities" [32]. Our assumed utility equation is a function of the consumption of non-electricity (C) and electricity goods (E^H) as follows, where U shows the consumer's utility and γ and δ are coefficients for the non-electricity and electricity consumption, respectively.

$$U_t = \left(C_t, E_t^H\right) = \frac{1}{1-\gamma}(C_t)^{1-\gamma} + \frac{1}{1-\delta}\left(E_t^H\right)^{1-\delta} \tag{5}$$

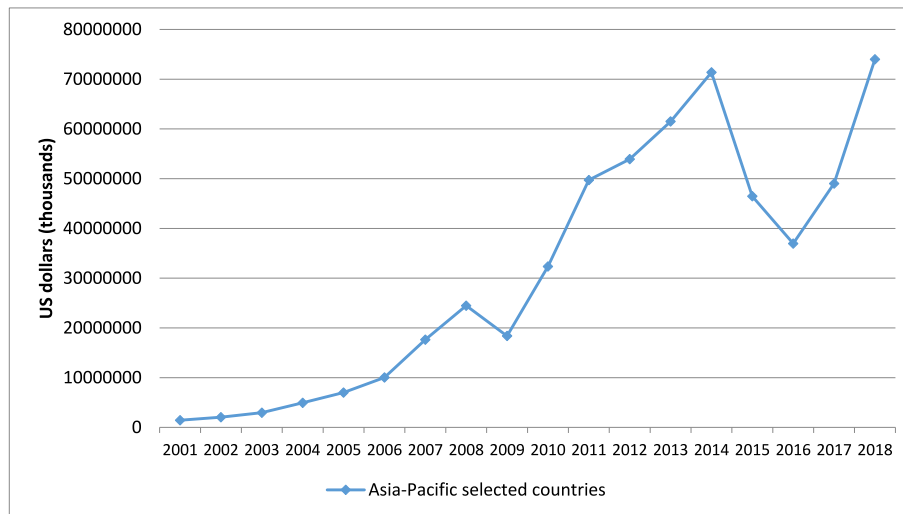Households maximize their utility according to their budget

Fig. 2. Energy exports from the Russian Federation to Asia and the Pacific, 2001–2018, US$ (thousands).
Source: Authors' compilation from BP Statistical Energy Review [1].

constraints, as shown in Equation (6):

$$S.t. \quad P_t^C C_t + e_t \left(P_t^E + T_t \right) E_t^H = Y_t^H \tag{6}$$

where P^C is the price of non-electricity goods, C is the consumption of non-electricity goods, P^E is the electricity tariff (which depends on fossil fuel prices), and T is the transportation costs (a function of distance). Y^H and e are the total income of the households and the exchange rate, respectively.

To maximize households' utility function to define the factors that determine electricity demand, we developed the Lagrange function, as in Equation (7):

$$\Gamma = U\left(C_t, E_t^H\right) - \lambda \left\{ P_t^C C_t + e_t \left(P_t^E + T_t \right) E_t^H - Y_t^H \right\} \tag{7}$$

We obtained the first-order conditions with respect to the E^H, C, and λ results in Equations (8)–(10):

$$\frac{\partial \Gamma}{\partial E_t^H} = \left(E_t^H\right)^{-\delta} - \lambda \left\{ e_t \left(P_t^E + T_t \right) \right\} = 0 \rightarrow E_t^H = f\left(e_t, P_t^E, T_t\right) \tag{8}$$

$$\frac{\partial \Gamma}{\partial C_t} = C_t^{-\gamma} - \lambda \left\{ P_t^C \right\} = 0 \tag{9}$$

$$\frac{\partial \Gamma}{\partial \lambda} = P_t^C C_t + e_t \left(P_t^E + T_t \right) - Y_t^H = 0 \tag{10}$$

As shown in Equation (8), a household's energy demand is a function of its exchange rate, electricity tariff, transportation costs (distance between exporter and importer). The total energy demand is equal to the combined energy demand of households and industries (Equation (11)).

$$E_t = E_t^I + E_t^H \tag{11}$$

According to the consumption theory, price, income level, and wealth are the main determinants of consumption. Here in this research, we do not consider wealth due to the macro-approach of the study; however, we added the importer's income level to the determinants of energy demand. Therefore, the total energy demand is a function of different factors, as shown in Equation (12):

$$E_t = f\left(P_t^E, T_t, e_t, Y_t\right) \tag{12}$$

where P^E is the electricity tariff, contingent on energy price; T is the transportation costs, a function of distance; e is the exchange rate between the energy exporter and importer; and Y_t is the economy's total gross domestic product (GDP), contingent on the households' income level (Y_t^H) and the total industry output (Y_t^I).

4. Data and empirical model specification

In this section, we used the variables obtained from the theoretical model in the previous section, namely energy export volume (LEV), economic growth (GRO), the difference in per capita income (DI), the bilateral exchange rate (BEX), and geographical distance (DIS). We also used two control variables, namely the sanctions imposed against Russia (SANC) and urbanization growth (URB). The empirical analysis was conducted and explored the determinants of the export pattern of Russian energy to the APR, and selected 17 sample countries from the APR region based on the imported energy volume from Russia in the last decade.

Our variables consisted of the real and dummy variables of sanctions. Our real variables were time-varying variables that had time series data over specific periods, and we always used dummy variable to capture the impacts of such qualitative economic variables as sanctions, wars, and the existence of common borders [33].

The quarterly data on GRO, URB, BEX, and DI were gathered from the Quarterly Public Sector Debt (QPSD) database developed by World Bank and the International Monetary Fund. We consulted the Centre

d'Études Prospectives et d'Informations Internationales (CEPII) for DIS and Trade Map for LEV. We gathered complementary data from authorities' websites in each country such as the National Bureau of Statistics of China (www.stats.gov.cn), Trade Map, Statistics Korea (www.Kostat.go.kr), Open Government Data Platform India (https://data.gov.in), Central Bank of Sri Lanka (www.cbsl.gov.lk), Department of Statistics Malaysia (www.dosm.gov.my), State Bank of Pakistan (www.sbp.org.pk/ecodata/index2.asp), Japan's Ministry of Economy, Trade and Industry (www.meti.go.jp), and the Federal State Statistics Service, Russia (www.gks.ru).

The quarterly series covered 2010–2017 for the APR. The main reason for selecting this period was the accessibility of quarterly energy trade data and the growth of the energy relationship between Russia and the APR since 2010.

Table 1 presents the primary descriptive data characteristics. The LEV (in this study, we used the HS Code 27 trade Map as the basis of energy export data) is measured in US dollars ($). Russia's energy exports to the APR had a mean of US$1.16 billion for 2010–2017. The mean of the selected APR countries' GRO was 5.3%. The DI between Russia and the APR from 2010 to 2017 was US$26,970.30 per person. The URB in selected APR countries was 3.2%, with a maximum of 10.9% and a minimum of −1.4% from 2010 to 2017. The BEX between the Russian ruble and the national APR currencies during 2010–2017 was an average of 493.8. Due to the nature of the gravity trade theory, we employed the BEX as the changes of ruble and each APR economies' national currencies in the form of panel data. Regarding geography, based on GeoDist data of CEPII, the maximum DIS between Russia and the 17 selected APR nations was 6963 km, and the minimum was 2853 km.

Fig. 3 shows the positive correlation between economic growth and Russia's energy exports to the APR. This is in line with Varahrami and Haghighat's [25] findings, which demonstrated the same relationship in selected OECD countries. The EXV from Russia to selected APR countries was positively related to URB, while their correlation with DI fluctuated and was negative. The relationship between GRO and BEX also fluctuated, but it was positive. Furthermore, the correlation between DIS and Russia's EXV to the APR was negative.

We empirically investigate the following model based on gravity trade theory and variables in natural logarithms:

$$\begin{aligned} lnLEXV_{ijt} = {} & \delta_1 \ln\left(GRO_{jt}\right) + \delta_2 \ln\left(DI_{ijt}\right) + \delta_3 \ln\left(URB_{jt}\right) + \delta_4 \ln\left(BEX_{ijt}\right) \\ & + \delta_5\left(SANC\right) + \delta_6 \ln\left(DIS_{ij}\right) + \varepsilon_{ijt} \end{aligned} \tag{13}$$

The coefficients $\delta_1, \delta_2, \delta_3, \delta_4, \delta_5$, and δ_6 represent the long-run elasticity estimates of Russia's energy exports to the APR with respect to GRO, DI, URB, BEX, SANC, and DIS. Based on the theory and correlation results, we expected that increased GRO and URB would lead to an increase in Russia's EXV to the APR, while DI, BEX, and SANC would remain unknown.

Regarding the DI, the estimated coefficient might prove the Linder hypothesis or the Heckscher–Ohlin approach. The Linder hypothesis claims that economies with similar per capita income levels have more overlapping demand, which should induce them to trade more intensively with each other [34]. However, Caporale et al. [35] explained that based on the Heckscher–Ohlin theory, differences in per capita income could motivate countries to trade more with each other.

We expected any increase in DIS as a proxy for transportation to reduce the energy trade between the countries. The dummy variable of SANC was related to the economic sanctions imposed by the West against Russia over political tensions regarding Ukraine since December 2014 [36]. The variable takes 1 over Q4 2014–Q4 2017; otherwise, it takes 0.

To estimate the coefficients, we used the generalized method of moments (GMM) in a panel-gravity framework for energy trade flows from Russia to 17 APR countries. The reliability of the GMM method has

Table 1

Variables' descriptive statistics.

Variables	Unit	Obs.	Mean	Std. Dev.	Max.	Min.
EXV	Thousand US$	544	1,166,305	39,692	41,226,438	0.0
GRO	%	544	5.3	3.8	22.5	−19.8
DI	US$ per person	544	26,970.3	21,352.7	101,352.6	473.8
URB	%	544	3.2	1.8	10.9	−1.4
BEX	Ruble to APR currency	544	493.8	1646.6	10,461.2	1.49
DIS	Kilometers	544	4838.5	1213	6963	2853

Notes: DI = difference of income; DIS = geographical distance; BEX = bilateral exchange rate; GRO = economic growth; EXV = energy export volume of Russia to the APR; URB = urban population growth.
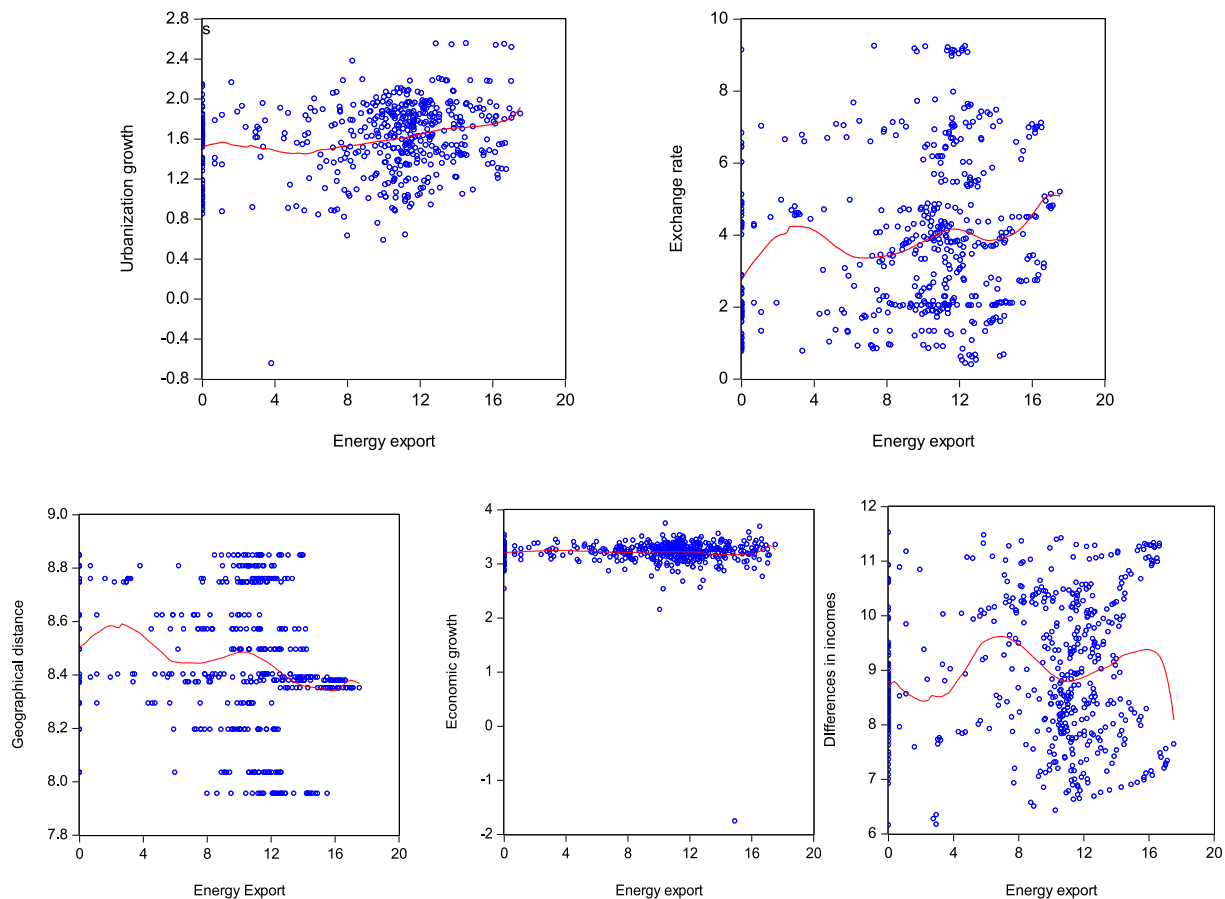Source: Authors' compilation.

Fig. 3. Correlation with the kernel fit line.
Source: Authors' compilation from Eviews 9.0

been proven by numerous scholars, such as Arellano and Bond [37]; Kahouli and Maktouf [38]; Lin [39]; and Martinez-Zarzoso et al. [40]. Arellano and Bond [37] argued that the GMM estimator, including the lagged endogenous variable as an explanatory variable, is more convenient for panel data because it yields more consistent and robust results in the presence of arbitrary heteroskedasticity. A general regression model in the form of a GMM is expressed as follows:

$$Y_{it} = \alpha + \beta Y_{it-1} + \gamma X_{it} + \eta_{it} + \varepsilon_{it} \tag{14}$$

where Y indicates the dependent variable (Russian energy export flows to the APR economies), and X represents all explanatory variables (GRO, BEX, URB, DI, DIS, and SANC). η_{it} denotes country-specific effects, and ε_{it} is the error term.

To derive reliable empirical estimations, we first had to conduct preliminary tests. Our first preliminary test was the variance inflation factor (VIF) to ascertain whether there was any multicollinearity in the

series. Our second preliminary test was the Hausman test to check for heterogeneity, clarifying the presence of random or fixed effects in our panel. Because the economies of Russia and the selected sample had experienced various exogenous and endogenous shocks, we used the next preliminary test to check for cross-sectional dependency in the series. The last preliminary test was the second-generation unit root test to ascertain whether the series was I(1) stationary or I(0) nonstationary.

We conducted two different diagnostic tests after running the GMM estimations. The first was the Arellano–Bond test for zero autocorrelation in the first-differenced errors, and the second was the Sargan test to verify the overidentifying restrictions.

5. Empirical analysis

Before we could estimate our econometric gravity model, we had to check for multicollinearity, heterogeneity, and cross-section

dependency in the series. Table 2 reports the results of the VIF (multi-collinearity among variables) and Hausman (to clarify the nature of the panel data series, i.e., random or fixed effects) tests.

The findings of the VIF test, presented in Table 2, showed low multi-collinearity between the cross-sections. Moreover, the results of the Hausman test proposed panel data with random effects. The next step was to verify the presence of cross-section dependence in the series. Table 3 shows the results of the cross-section dependence (CSD) test.

The results of the CSD test, reported in Table 3, reveal cross-sections in all series. This meant that our samples in the APR shared the same characteristics. Generally, in situations where there is low multi-collinearity and cross-section dependence in the variables, it is necessary to check the stationarity of the variables. Here, we conducted the second-generation panel unit root test (Pesaran's [41] CIPS test) with the null hypothesis of all series being I(1). The results of this test are shown in Table 4.

The Pesaran's [41] panel unit root test (Table 4) showed that all series were I(0).

After conducting all the necessary preliminary tests, we ran the Arellano–Bond dynamic GMM estimation to ascertain the coefficients. Table 5 shows the results of the GMM estimation.

Table 5 shows the following results:

- First, GRO's effect was highly significant and positive, indicating that a 1% increase in the economic growth of the selected APR economies led to an increase in Russian EXV to the region by nearly 0.02%. This is in line with Rasoulinezhad [42]; who noted a positive relationship between economic size and trade flows.
- Second, the impact of DI on Russia's energy exports to the APR was statistically significant and negative, supporting the Linder hypothesis (i.e., the more two countries are similar in terms of income, the more they might trade).
- Third, URB's effect was positive and statistically significant. Russia's energy exports to the APR increased by approximately 2.17% for every 1% increase in the region's urban population. This result is in line with Kurniawan and Managi [43]; who showed a positive relationship between urban population and trade flows.
- Fourth, BEX had a positive sign, which meant that a 1% depreciation of the APR nations' currencies against the Russian ruble would accelerate EXV by about 0.8%. Thus, when the selected APR nations' national currencies depreciated, their import costs would increase and energy resources would become more expensive in their domestic currencies, although their export of final products would be more competitive. Therefore, they would exhibit a greater demand for energy and import more from other countries, including Russia. Furthermore, because energy is a Russian power tool in the region [44], any depreciation of the importers' currencies against the ruble (a stronger Russian currency against its energy trading partner)

Table 2
VIF statistics and Hausman test results.

Independent variables	Explanatory variables					
	LEXV	LDI	LGRO	LURB	LBEX	LDIS
LEXV	–	1.13	1.03	1.44	1.29	1.30
LDI	1.58	–	1.10	1.42	1.29	1.05
LGRO	1.14	1.31	–	1.25	1.33	1.48
LURB	1.60	1.43	1.09	–	1.19	1.53
LBEX	1.22	1.04	1.46	1.51	–	1.35
LDIS	1.12	1.53	1.39	1.04	1.51	–
Mean VIF	1.33	1.28	1.21	1.33	1.32	1.34
Chi^2 (7)	11.52					

Notes: (L) indicates variables in the natural logarithms. DI = difference of income; DIS = geographical distance; BEX = bilateral exchange rate; GRO = economic growth; EXV = energy exports of Russia to the APR; URB = urban population growth.
Source: Authors' compilation.

Table 3
CSD test results.

Variables	CSD test	Corr.	Abs. (corr.)	Significant at 1% level
LEXV	5.15	0.235	0.235	Yes
LGRO	10.83	0.718	0.718	Yes
LDI	7.73	0.510	0.510	Yes
LURB	8.95	0.588	0.588	Yes
LBEX	6.25	0.317	0.317	Yes
LDIS	8.44	0.604	0.604	Yes

Notes: (L) indicates variables in the natural logarithms. DI = difference of income; DIS = geographical distance; BEX = bilateral exchange rate; GRO = economic growth; EXV = energy exports of Russia to the APR; URB = urban population growth.
Source: Authors' compilation.

Table 4
Pesaran [41] panel unit root test results.

Variables	Without trend	With trend
LEXV	0.243	1.683
LGRO	0.311	−0.849
LDI	0.269	−0.790
LURB	−0.782	−0.811
LBEX	0.218	1.823
LDIS	0.392	−0.833

Notes: (L) indicates variables in the natural logarithms. DI = difference of income; DIS = geographical distance; BEX = bilateral exchange rate; GRO = economic growth; EXV = energy exports of Russia to the APR; URB = urban population growth. * denotes statistically significant at 5% levels.
Source: Authors' compilation.

Table 5
Arellano–Bond dynamic GMM model estimations.

Explanatory variables	Coefficients	Significant at 1% levels
Constant	−1.738	Yes
LGRO	0.024	Yes
LDI	−0.149	Yes
LURB	2.174	Yes
LBEX	0.882	Yes
LDIS	−0.092	Yes
SANC	0.004	Yes
Number of observations	544	
Periods included	32	
Cross-sections included	17	
Wald Chi^2 (5)	462.28	Yes

Notes: (L) indicates variables in the natural logarithms. DI = difference of income; DIS = geographical distance; BEX = bilateral exchange rate; GRO = economic growth; EXV = energy exports of Russia to the APR; URB = urban population growth.
Source: Authors' compilation.

would lead to stronger energy export power. In other words, a stronger ruble would lead to a stronger political position for Russia (Russia's bargaining power in the energy market would rise), increasing its energy exports to importers in Asia. This is in line with Urbanovsky [45]; who argued that a weaker Russian ruble might lead to an economic downturn in Russia and vice versa.

- Fifth, the impact of the time-invariant factor (sanctions imposed by the West against Russia) was positive and statistically significant. Thus, the sanctions did not constitute a barrier to Russia's energy exports to the APR and enabled it to become a trade pivot from the West to the East.
- Sixth, there was a negative nexus between DIS and the energy trade flows between Russia and the selected APR economies. Any increase in geographical distance as a proxy for transportation costs lowered Russian energy exports to the region. This result is in accordance

with Rasoulinezhad [46,47], who demonstrated Russia's geographical shift to the East under sanctions.

As the final stage in the empirical estimations, we carried out diagnostic tests to verify the model's characteristics using the Arellano–Bond and Sargan tests, yielding the following results:

The results shown in Table 6 strongly rejected non-autocorrelation; thus, the Arellano–Bond model assumptions were satisfied. In addition, the Sargan test findings showed that there were no overidentifying restrictions. In other words, our model was suitable.

6. Robustness check

To ensure the reliability of the empirical estimations reported in Section 5, we conducted an additional estimation method on the data. Table 7 shows the results of applying the panel fixed-effect estimator and depicts the robustness and validity of earlier the results.

As shown in Table 7, the increase in GRO of the selected APR economies had a positive and statistically significant impact on Russian EXV to the countries. Moreover, the negative and statistically significant coefficient of DI was also evident, supporting the Linder hypothesis. The coefficient expressing the relationship between URB and Russian EXV was also positive and statistically significant. Furthermore, the robustness check proved the positive coefficients of BEX and SAN and the negative coefficients for DIS.

The similarities in the coefficients' signs of the variables in the two different estimators (GMM and random effects) confirmed the reliability and validity of our estimated results, based on which we have expressed the concluding remarks in the next section.

7. Conclusion and policy implications

This study represented an empirical attempt to econometrically model Russia's energy export pattern among 17 APR nations from 2010 to 2017. To conduct our research, we employed the gravity theory framework and an econometric approach, namely the GMM panel model for quarterly data for 2010–2017 for 17 countries. To obtain reliable estimation results, we carried out various preliminary diagnostic tests, including the VIF to identify any multicollinearity in the series, the Hausman test to check for heterogeneity, the panel unit root test to determine whether the series were I(1) stationary or I(0) nonstationary, the Arellano–Bond diagnostic test for zero autocorrelation in the first-differenced errors, and the Sargan diagnostic test to verify the overidentifying restrictions.

By modeling the energy trade from Russia to the APR and estimating using our GMM model, we found that the process followed the Linder hypothesis—that is, the more similarities between the APR and Russia in terms of the factors studied, the more likely the APR was to import energy from Russia. This finding contrasts with Rasoulinezhad and Jabalameli's [48] finding that Russian export patterns in manufactured goods and raw material commodities were based on the Heckscher–Ohlin hypothesis.

Our study found that economic growth had a positive influence on Russian energy exports to the APR, where greater economic growth or production levels had resulted in increased energy demand and consumption. Our finding of the positive relationship between economic

Table 6
Diagnostic test results for GMM estimation.

Statistics	AR(2)z	Chi^2
Arellano–Bond test	−2.62**	–
Sargan test	–	3412.92***

Notes: ** and *** indicate statistical significance at the 1% and 5% levels, respectively.
Source: Authors' compilation

Table 7
Robustness check via panel random effect estimation.

Explanatory variables	Coefficients	Significant at 5% levels
LGRO	0.001	Yes
LDI	−0.002	Yes
LURB	0.053	Yes
LBEX	0.013	Yes
LDIS	−0.00	Yes
SANC	0.001	Yes
Number of observations	544	
Periods included	32	
Cross-sections included	17	

Notes: (L) indicates variables in the natural logarithms. DI = difference of income; DIS = geographical distance; BEX = bilateral exchange rate; GRO = economic growth; EXV = energy exports of Russia to the APR; URB = urban population growth.
Source: Authors' compilation.

growth and energy demand was in line with Rasoulilnezhad [46,47] and Saidi and Hammami [49] but contrasts with Karanfil [50]; who did not find a positive relationship between the two.

We also found that a depreciation of the national APR currencies economies against the Russian ruble was likely to accelerate Russian energy export volume. This result is similar to Arize's [51] discovery of a negative relationship between the exchange rate and import flows, but contradicts Chaudhary, Hashmi, and Khan's [52] finding of no relationship between the two variables in the short run. Despite these interesting points concerning bilateral exchange rates, employing separate exchange rates or a variety of currencies would be a useful topic for further studies.

Our findings also indicated that the sanctions against Russia since 2014 stimulated an increase in Russian energy exports to the APR. This finding reflects Russia's "Pivot to Asia" in response to the West's sanctions, as demonstrated by such scholars as Yennie-Lindgren [9]. As Nasre Esfahani and Rasoulinezhad [53] argued, the sanctions induced Russia to conduct an economic policy of Asianization and de-Europeanization.

The results showed a positive link between urban population growth and energy imports to the APR from Russia. Russian energy exports to the APR increased by approximately 2.17%, given a 1% increase in regional urban population growth. This result is in line with Brakman and Marrewijk [54]; who found a causal relationship between population and trade flows in different nations. A higher level of urban population growth means a higher need for commodities, leading to increased trade flows. However, as Yuan and Guanghua [55] noted, many countries are adopting policies geared toward imports to increase their urbanization.

We also found a negative relationship between geographical distance and Russia's energy exports to the APR, meaning that any increase in geographical distance led to greater transportation costs, which are an obstacle to trade between nations.

Modeling energy trade patterns between Russia and the APR economies using various variables has demonstrated that these variables do not operate alone. Numerous other variables, including energy prices, geographical borders, and financial stability, could affect Russia's energy exports to the region. Therefore, we recommend that future studies consider new variables such as the energy security index and patterns to model the energy trade between nations, especially to determine the impact of Russia–APR energy trade on regional energy security. Furthermore, the Russian trade pivot to the east and increased energy consumption in the APR have augmented issues of energy insecurity in the region. Here, we recommend some topics for further research. First, there needs to be an assessment of the establishment of an energy trading hub. Similar policies have been suggested by Tong et al. [20]; who argued that any gas trading hub might create regional benchmark prices, a favorable strategy for the APR. The establishment of a gas hub

like a gas OPEC (Organization of the Petroleum Exporting Countries) would positively contribute to the accessibility and affordability of LNG and improve the region's energy security by regulating gas production and sales to leading consumers. A key issue regarding the creation of a gas hub pertains to liquidity, which is one of the most important requirements for successful trading; liquidity in the APR markets might be improved through the standardization of traded contract terms and conditions. Furthermore, developing financial markets (physical and futures) might be essential to providing a liquidity hub in this region. Import diversification might also reduce the region's energy insecurity. This recommendation is in line with Shaikh et al. [56]; who showed a positive relationship between supplier diversification and LNG supply security. Taghizadeh-Hesary et al. [57] demonstrated the importance of energy supplier diversification in Japan, a country that flourishes under self-dependency and energy security. Moreover, this policy might help countries reduce CO_2 emissions from fossil fuels [58,59].

Another recommendation for future study is the presence or absence of a land border with Russia as an important independent variable in ensuring the energy security of an importing country. For example, China's geographical location makes it a significantly more profitable market than India since constructing gas and oil pipelines to India would involve high risks, including dependence on the countries between India and Russia. For India and many other countries in the region, sea transport remains the only option, but it is far from safe, as evidenced by the March 2021 incident in which a container ship blocked traffic through the Suez Canal.

Credit author statement

Farhad Taghizadeh-Hesary: Conceptualization, Validation, Supervision, Writing- Reviewing and Editing. **Ehsan Rasoulinezhad**: Conceptualization, Data curation, Software, Data Analysis, Writing-Original draft preparation. **Tapan Sarker**: Writing- Reviewing and Editing. **Naoyuki Yoshino**: Modelling. **Nawazish Mirza**: Writing-Reviewing and Editing.

Compliance with ethical standards

This article does not contain any studies with human participants or animals performed by any of the authors.

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Declaration of competing interest

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