ADBI Working Paper Series

RUSSIAN FEDERATION–EAST ASIA LIQUEFIED NATURAL GAS TRADE PATTERNS AND REGIONAL ENERGY SECURITY

Ehsan Rasoulinezhad,
Farhad Taghizadeh-Hesary,
Naoyuki Yoshino, and
Tapan Sarker

No. 965
June 2019

Asian Development Bank Institute

Ehsan Rasoulinezhad is assistant professor at the Faculty of World Studies of the University of Tehran in Tehran. Farhad Taghizadeh-Hesary is assistant professor at the Faculty of Political Science and Economics of Waseda University in Tokyo. Naoyuki Yoshino is dean and chief executive officer of the Asian Development Bank Institute and professor emeritus of Keio University in Tokyo. Tapan Sarker is director of engagement and senior lecturer at the Department of Business Strategy and Innovation and research chair at the Griffith Centre for Sustainable Enterprise, Griffith Business School, Griffith University, Australia.

Suggested citation:

Rasoulinezhad, E., F. Taghizadeh-Hesary, N. Yoshino, and T. Sarker. 2019. Russian Federation–East Asia Liquefied Natural Gas Trade Patterns and Regional Energy Security. ADBI Working Paper 965. Tokyo: Asian Development Bank Institute. Available: https://www.adb.org/publications/russian-federation-east-asia-liquefied-natural-gas-trade-patterns-security

Please contact the authors for information about this paper.

Email: farhad@aoni.waseda.jp

Asian Development Bank Institute
Kasumigaseki Building, 8th Floor
3-2-5 Kasumigaseki, Chiyoda-ku
Tokyo 100-6008, Japan

Tel: +81-3-3593-5500
Fax: +81-3-3593-5571
URL: www.adbi.org
E-mail: info@adbi.org

Abstract

East Asia remained the biggest market for liquefied natural gas (LNG) in 2018. The Russian Federation has a clear vision to develop its East Asia LNG projects to provide a bigger share of Asian LNG imports. This paper models Russian Federation–East Asia LNG trade patterns via the gravity trade theory, which is shown to fit well with energy trade patterns. The findings reveal that a 1% increase in population growth in the People's Republic of China, Japan, and the Republic of Korea increases Russian Federation LNG exports by nearly 3.43%, and economic growth by 6.16%, while any increase in geographical distance decelerates LNG exports to the selected East Asian economies by nearly 7.3%. This means that the close proximity of the Russian Federation to East Asia is an advantage for its LNG exports. Furthermore, the West's sanctions against the Russian Federation are a positive influencing factor on the latter's LNG export volume to East Asia. Our findings recommended some policies such as construction of a gas trading hub in Asia, increasing regional pricing power, and energy import diversification and shorter distances between the Russian Federation (exporter) and East Asia (importer) to improve energy security in this region.

Keywords: gravity trade modeling, LNG trade, energy security, Russian Federation, East Asia

JEL Classification: Q37, R11, F14

Contents

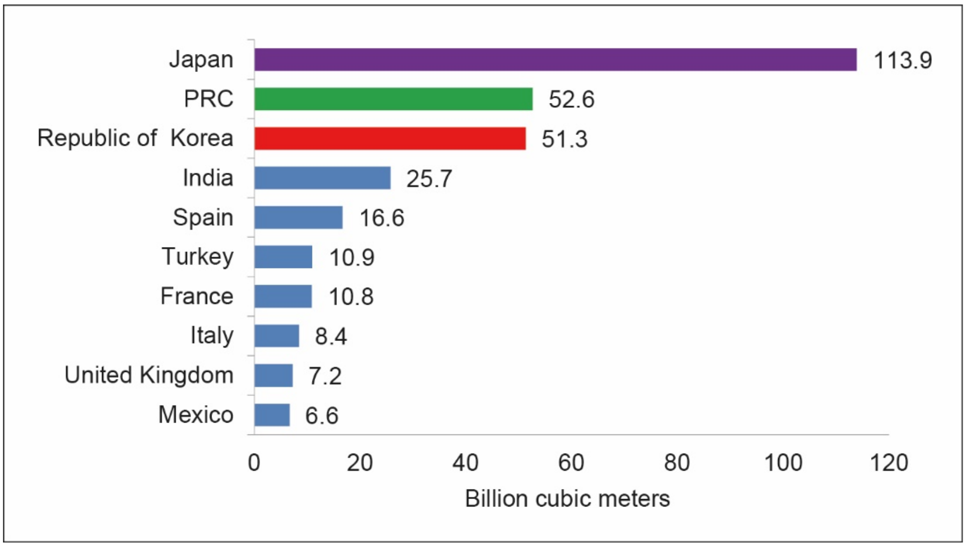
1. INTRODUCTION

The role of natural gas as a preferred source of energy has increased in recent decades. In 2017, global natural gas production hit a new record of 3.768 trillion cubic meters. This is a 3.6% increase compared to 2016 and constitutes the largest increase since 2010. In fact, natural gas production has been rising since the economic crisis of 2009, with a compound annual growth rate of 2.6%. In 2017, global demand for natural gas increased by 3.2% compared to 2016, rising to 3.757 trillion cubic meters. This was the eighth consecutive annual increase. Since 1990, global natural gas consumption has grown at an average of 6.3% per year. Consumption growth has been even stronger in the People's Republic of China (PRC), averaging 13.1% per year over the past 20 years. Global demand for natural gas is forecast to increase at an average of 1.6% over the next 5 years, with emerging Asian markets as the main engine for demand. The PRC alone accounts for a third of global demand growth to 2022 thanks in part to the country's "Blue Skies" policy and the strong drive to improve air quality (IEA 2018).

Several studies discussed the positive role of natural gas on different nations' economic development. Balitskiy et al. (2016) and Aung, Saboori, and Rasoulinezhad (2017) proved that the relationship between gas consumption and economic development is positive for the European Union. Fadiran, G., Adebusuyi, and Fadiran, D. (2019) believed that in nations with a high level of gas consumption, all energy-based industries can perform positively and affect the economic growth of that nation. According to the International Renewable Energy Agency's (IRENA) Global Energy Transformation Report, the future of energy sources will be focused on renewables (in line with Gielen et al. [2019], the share of renewables in total primary energy supply would rise from 14% in 2015 to 63% in 2050) and only natural gas will be heavily used among non-renewables. Zou et al. (2016) predicted that the natural gas annual production peak will be around 2060 and will play a pivotal role in sustainable energy development.

Many scholars have argued about the importance of substituting natural gas for crude oil or coal. For instance, Thomson, Carbett, and Winebrake (2015) and Barreto (2018) expressed that liquefied natural gas (LNG) can be an important source of energy that minimizes air pollutants, such as sulfur oxides. In comparison with other popular non-renewable energy resources, using natural gas is better for the climate. Dhameliya and Agrawal (2016) noted various advantages of using natural gas, such as its ease of production, great availability, and lower transportation cost, and argued that LNG as a green fuel has become a new hot spot for global energy markets. Similarly, Withers et al. (2014) mentioned that LNG can help nations diversify energy supplies and mitigate transportation's climate and air quality impact. Saboori et al. (2017) proved that oil consumption of Asia-Pacific nations has a positive link with their amount of CO_2 emissions, thus impelling them to shift to cleaner energy sources. In 2017, Asia remained the biggest market for LNG, taking in 53.6% of global supply. Demand in Asia and the Pacific continues to be led by Japan (113.9 billion cubic meters), with the PRC (52.6 billion cubic meters) and the Republic of Korea (51.3 billion cubic meters) being a distant second and third, respectively. However, it should be mentioned that these three East Asian nations are among the top global LNG importers of 2017, as shown in Figure 1.

Figure 1: Top Global LNG Importers in 2017
(billion cubic meters)



LNG = liquefied natural gas, PRC = People's Republic of China.

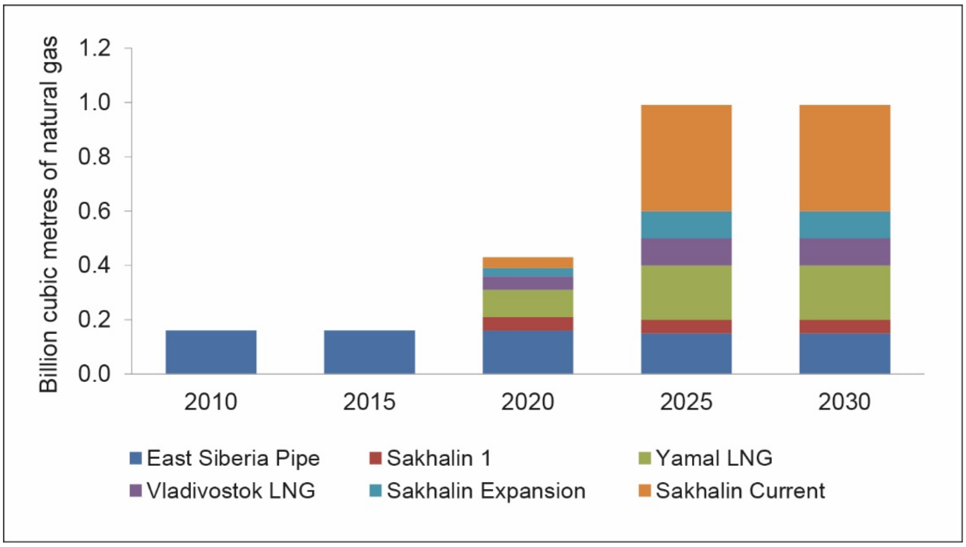
Source: Authors' compilation from statistica.com.

However, dependency on energy imports may be considered a root of energy insecurity (according to Charp and Jewell [2014], energy insecurity can be defined based on 4As: availability, accessibility, affordability, and acceptability). Energy security can be defined as an adequate and reliable supply of energy resources at a reasonable price (Bielecki 2002). Energy security in the literature, in a broader sense, implies the availability of energy resources. This can be measured further under the concept of diversification, or hedging. There are three aspects of diversification: variety, balance, and disparity (Stirling 2010). Variety asks how many options there are, while balance checks how dominant one option is, and disparity examines how different or similar all options are. In recent years, the issue of energy insecurity has been an overriding challenge in Asia, particularly for developing countries (Taghizadeh-Hesary et al. 2019).

When an economy depends on particular imports, it would be a potential threat for its security. The prediction of increased East Asian LNG imports raises the importance of energy insecurity in this region economies want to rely on few LNG exporters (Qatar and Australia) as they do now.

Shares of Russian Federation LNG in the East Asian import basket are smaller than the shares of Qatar and Australia, and it is mainly exported to Europe. However, the Russian Federation has a clear vision to develop its Eastern LNG projects to provide a bigger share of Asia LNG imports. According to the Russian Federation long-run 2030 strategy, its gas industry would be focused on the East, with export volumes of nearly 75 billion cubic meters by 2030 (Henderson 2011). To this end, the Russian Federation is trying to expand its Eastern LNG fields to cover its potential exports to East Asia, and the world as well. Henderson and Stern (2014) predicted East Siberia Pipe and Vladivostok LNG will play the most important role in the Russian Federation's gas exports to Asia. Its estimations are shown in Figure 2:

Figure 2: Expectations of the Russian Federation's Gas Exports to Asia



Source: Henderson and Stern (2014).

Although a number of studies (e.g., Fortescue 2016; Raj et al. 2016; and Shibasaki et al. 2018) considered Russian Federation LNG exports to Asia and Pacific nations, the authors did not find any serious and in-depth work studying the LNG trade pattern between the Russian Federation and East Asian nations. Hence, the novelty of this paper is to address the trade pattern characteristics of LNG between a big LNG exporter (Russian Federation) and three big LNG importers in Asia (the PRC, Japan, and the Republic of Korea). To this end, we employ an advanced econometric estimation methodology under the gravity theory trade construction.

The rest of this paper is organized as follows: Section 2 represents a brief review of existing literatures. Section 3 describes the theoretical background of the paper. Section 4 discusses data and empirical model specification. Section 5 provides the empirical analysis and the final section concludes the paper and provides some policy recommendations.

2. LITERATURE REVIEW

The related literature can be divided into two main strands: Asian energy security, especially East Asia, and all earlier studies about the LNG trade.

In the first strand of literature, diversity is the most frequently employed aggregate energy security indicator. Yao and Chang (2014) mentioned the availability of energy resources, applicability of technology, acceptability by society, and affordability of energy resources (4As) as four pillars for quantifying the level of energy security. In addition, there are several studies that proposed that versatility of the fossil fuel import origins will increase the energy security level (Yao and Chang 2014; Tongsopit et al. 2016).

Calder (2006) investigated the role of the PRC vis-à-vis global energy insecurity, and concluded that its prodigious needs necessitate promoting efficiency, diversifying its energy basket, improving domestic energy infrastructure, and reducing reliance on sea lanes. In another study, Sovacool (2013) analyzed the level of energy security in different Asian nations and showed that Myanmar was the country that saw its energy security deteriorate most. In addition, Malaysia achieved its diversification and almost universal energy access only with large subsidies and one of the fastest growth rates in greenhouse gas emissions. Rasul (2014) focused on the linkages between food, water, and energy security in India, and found that, along with cross-sectoral integration to improve the resource-use efficiency and productivity of the three sectors, regional integration between upstream and downstream areas is critical. Stegen (2015) found that, as part of its global energy strategy, which shows domestic, regional, and global energy security together, the PRC has secured the resources of several Central Asian states for its "Silk Road" plan. Matsumoto and Andriosopoulos (2016) analyzed energy security in East Asia under climate mitigation and proved empirically that, in order to reduce CO_2 emissions, the PRC, Japan, and the Republic of Korea need to change their energy composition from fossil fuels to renewables.

Taniguchi et al. (2017) investigated energy security in the Asia and Pacific region with a particular focus on water and food securities and showed the relationships between self-sufficiency (i.e., self-production) and diversity for water, energy, and food in this region. Moshin et al. (2018) proposed a composite index for evaluating the oil supply risk of South Asian countries. Their major findings concluded that India is the least vulnerable to oil prices, while Afghanistan and Bangladesh are the most vulnerable. Ralph and Hancock (2019) analyzed the linkages between energy security, transnational politics, and electricity exports by using five dimensions of availability, affordability, technology development and efficiency, environmental and social sustainability, and regulation and governance in Australia and Southeast Asia. They concluded that Australia's stalled energy politics and Indonesia's sudden policy shifts are two main components affecting their mutual energy security. Taghizadeh-Hesary et al. (2019) found a linkage between energy security and food security in a panel of eight Asian economies during 2000–2016. Their results suggest an optimal combination of renewable and nonrenewable energy resources will be in favor of not only the energy security but also food security.

The second strand of literature focuses on the LNG trade, which has drawn much attention from researchers. Cabalu and Manuhutu (2009) examined the relative vulnerability of eight gas-importing countries in Asia in 2006 using principal component analysis for four market risk indicators. This showed that there are significant differences in the values of individual and overall indicators of gas vulnerability among countries. Wood (2012) reviewed the global LNG trade, particularly in two major regions of Asia and Europe, and depicted the complexity of its commercial, political, and technical drivers. Tong, Zheng, and Fang (2014) analyzed establishing a natural gas trading hub in the PRC and concluded that its supporting policies on the natural gas sector, along with the initiation of spot and futures markets, the rapid growth of gas production, and highly improved infrastructures, as well as Shanghai's advantageous location, give it more advantages than countries such as Malaysia, Japan, and Singapore. Chen et al. (2016) focused on trade competition patterns of the global LNG trade by showing networks developing from 2005 to 2014. The study revealed that some European countries, such as Spain and Belgium, chose to re-export their LNG because of the reduced demand caused by their weak economies. Moreover, the shale gas from the US has not significantly affected the LNG export trade pattern.

Kim (2017) checked the changes in the Northeast Asian energy landscape based on the decline in global oil prices and concluded that the Russian Federation will seek to keep US LNG in check through price negotiations and that the evolution of an Asian gas hub will be influenced by how the Russian Federation and the PRC reconsider their energy strategies. Holzer et al. (2017) investigated potential effects of LNG trade shifts on transfer of ballast water and biota by ships and 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. The results predicted an approximate 90-fold annual increase in LNG-related ballast water discharge to the US by 2040 (42 million m^3).

Zhang et al. (2018) investigated the driving factors of global LNG trade flows by applying the gravity model over the period of 2004–2015. They found out that pipeline natural gas has a significant substitute effect on the LNG trade within the global model. Furthermore, the LNG trade in Asia is more sensitive to import prices and research and development investment than in the global model. Varahrami and Haghighat (2018) analyzed the effects of the LNG product in the Organisation for Economic Co-operation and Development countries by using the dynamic panel method for seasonal data from 2011–2015. The estimation results proved that LNG demand in the selected importing countries is relatively reversible in the short- and long-term.

Overall, it can be concluded from the existing literature that no serious studies focus on LNG trade flows between the Russian Federation and the Asia and Pacific region. Hence, our paper is the first one to consider this topic and exploring the Russian Federation–East Asia LNG trade pattern by employing Panel-Gravity trade model.

3. THEORETICAL BACKGROUND

This section's theoretical background supports the empirical variables and empirical model that will be created in section 4.

LNG is mainly for electricity generation. In this section, we assume that it is consumed only in two main sectors and that it is generated only by LNG. This means demand for LNG is coming from two groups. Group one is the industry sector and the second group is the residential sector (households).

3.1 Industry's LNG demand

Eq. 1 shows the production function of industry, assumed to be in the form of Cobb-Douglas:

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

Where Y^I is the total output of industry, K is the capital input, L is the labor input, and E^I is the LNG input of industry. We are assuming that there is constant return to scale. α is the elasticity of production of capital, β is the elasticity of production of labor, and the elasticity of production of LNG is equal to $1-\alpha-\beta$.

Firms in this sector are maximizing their profit, as shown in Eq. 2:

$$Max\, \pi_t = P_t^Y Y_t^I - r_t K_t - w_t L_t - e_t (P_t^E + T_t) E_t^I \quad (2)$$

Where π is the sector's profit, P^Y is the price of the final products of industry, r denotes the interest rate, w denotes the wage rate, e denotes the exchange rate, P^E

denotes electricity tariff that depends on LNG prices in dollars, and T denotes the transportation costs in dollars, which is function of the distance between the LNG exporter and importer.

Eq. 3 shows the first order condition of profit with respect to E^I:

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

The LNG demand is represented in Eq. 4:

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

As shown, industry's LNG demand is a function of the elasticities of production of labor and capital, the real output of industry sector, the price of LNG, the exchange rate, and the transportation cost, which is a function of distance between the supplier and consumer.

3.2 Residential LNG Demand

Eq. 5 is the utility function of households, which is a function of the consumption of non-electricity goods (C) and electricity (E^H):

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

Households are maximizing their utility with respect to their budget, which is the constraint, as shown in Eq. 6:

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

Where P^C denotes price of non-electricity goods, P^E denotes the electricity tariff, which depends on LNG prices denominated in dollars, and T denotes the transportation costs in dollars, which is function of distance; Y^H is total income of the households.

In order to maximize the utility function of households for defining the factors that determine electricity demand, we develop the Lagrange function, as in Eq. 7:

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

Obtaining the first-order conditions with respect to the E^H, C, and λ results in Eqs. 8–10:

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

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

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

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

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

Therefore, the total LNG demand is a function of different factors, as shown in Eq. 12:

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

Where P^E is the electricity tariff which is depending on LNG price, and T denotes the transportation costs, which is function of distance, e is the exchange rate between the LNG exporter and importer, and Y_t is the total gross domestic product of the economy, which depends on the income level of households (Y_t^H) and the total output of the industry (Y_t^I).

4. DATA AND EMPIRICAL MODEL SPECIFICATION

In this section, we use the variables obtained from the theoretical model in the previous section to conduct our empirical analysis and explore the determinants of the export pattern of Russian Federation LNG to East Asia. Here, we need the following real and dummy variables:

- LNG export volume (LNGE)
- Economic growth (GRO)
- Difference in per capita income (DI)
- Population growth (URB)
- Bilateral exchange rate (EX)
- Sanctions (SANC)
- Geographical distance (DIS)

In addition to the theoretical model variables, we added population growth and sanctions as two controls. As documented in the literature, LNG is a modern fuel and the consumption of it is a function of population growth; sanctions are another factor that shapes Russian Federation export patterns.

We gather data from World Bank Development Indicators, the Centre d'Études Prospectives et d'Informations Internationales (CEPII), and the Federal State Statistics Service (www.gks.ru). Our annual series covers the period 2010–2017 for East Asia.

Table 1 shows the primary descriptive characteristics of our data. LNG export volume is measured in million tons. The Russian Federation's LNG exports to East Asia has a mean of 3.53 million tons over the period 2010–2017. The mean of East Asian economic growth is 4.27%. It has a maximum and minimum of 10.6% (PRC in 2010) and –0.11% (Japan in 2011) during 2010–2017, respectively. The differences in per capita income between the Russian Federation and East Asia during the period of 2010–2017 takes the mean of $12,444.40 per person. The average of population growth in East Asia is 0.30%, whereas it takes the maximum of 0.76% (Republic of Korea in 2011) and minimum of –0.18% (Japan in 2011) from 2010 to 2017. The bilateral exchange rate between the Russian Federation ruble and the PRC yuan, the Japanese yen, and the Republic of Korea won during 2010–2017 takes the average of 9.85. It has a maximum and minimum of 38.06 and 0.09, respectively. Regarding geography, based on GeoDist data of CEPII, the maximum distance between the Russian Federation and the three East Asian nations is 7,486.39 km, while the variable takes the minimum of 5,795 km.

Table 1: Variables' Descriptive Statistics

Variables	Unit	Mean	Std. Dev.	Max.	Min.
LNGE	Mln tons	3.53	3.36	9.40	0.00
GRO	%	4.27	3.02	10.60	–0.11
DI	$ per person	12,444.40	14,901.08	33,382.70	–9,096.60
PGR	%	0.30	0.31	0.76	–0.18
EX	Ruble/currency	9.85	13.76	38.06	0.09
DIS	Kilometer	6,631.78	690.58	7,486.30	5,795.00

DI = difference of incomes, DIS = geographical distance, EX = bilateral exchange rate, GRO = economic growth, LNGE = liquefied natural gas exports of Russian Federation to East Asia, PGR = population growth.

Source: Authors' compilation.

Table 2 shows how the correlation between economic growth and Russian Federation LNG exports to East Asia is positive. This is in line with Varahrami and Haghighat's 2018 findings that proved this linkage in selected Organisation for Economic Co-operation and Development countries. LNG exports are positively related to bilateral exchange rate, population growth, and differences in per capita income. The relation between economic growth and bilateral exchange rates and differences in per capita income is negative.

Table 2: Correlation Matrix

	LGRO	LLNGE	LEX	LPGR	LDI
LGRO	1.00	0.13	–0.36	0.46	–0.23
LLNGE	0.13	1.00	0.17	0.31	0.11
LEX	–0.36	0.17	1.00	–0.51	0.49
LPGR	0.46	0.31	–0.51	1.00	–0.51
LDI	–0.23	0.11	0.49	–0.51	1.00

LDI = logarithm of difference of incomes, LEX = logarithm of bilateral exchange rate, LGRO = logarithm of economic growth, LLNGE = logarithm of liquefied natural gas exports of Russian Federation to East Asia, LPGR = logarithm of population growth.

Source: Authors' compilation from Eviews 9.0.

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

$$lnLNGE_{ijt} = \delta_1\, ln\big(GRO_{jt}\big) + \delta_2 \ln(\,DI_{ijt)} + \delta_3\, ln\big(PGR_{jt}\big) + $$
$$ + \delta_4\, ln(EX_{ijt}) + \delta_5\, SANC + \delta_6\, ln(DIS_{ij}) + + \varepsilon_{ijt}$$

The coefficients δ_1, δ_2, δ_3, δ_4, δ_5, and δ_6 represent the long-run elasticity estimates of Russian Federation LNG exports to East Asia with respect to economic growth, difference in per capita income, population growth, bilateral exchange rate, sanctions, and geographical distance. We expect that increased economic and population growth lead to an increase in Russian Federation LNG export volumes to East Asia, while the signs of difference in per capita income, bilateral exchange rate, and sanctions are vague. Moreover, any increase in geographical distance as a proxy for transportation cost is expected to lower LNG trade between these countries.

In what follows, we begin by testing for unit roots in our series. Three popular panel unit root tests, namely Levin, Lin & Chu (LLC), ADF-Fisher Chi-Square, and Philips-Perron-Fisher Chi-Square are conducted here. If these series are non-stationary in our panel, we try to find out the existence of long-run co-integration linkage. Finally, we use the Fully Modified OLS (FMOLS) estimator as one of the most popular estimators of the co-integrating panel model (see, e.g., Nasre Esfahani and Rasoulinezhad 2016; Rasoulinezhad 2017) to discover which of the interactions between our variables will reveal the LNG export pattern between the Russian Federation and East Asia.

5. EMPIRICAL ANALYSIS

Before our econometric gravity model can be estimated, the stationary and co-integration of series needs to be determined. We used standard panel unit root tests, namely Levin, Lin & Chu (LLC), ADF-Fisher Chi-Square, and Philips-Perron-Fisher Chi-Square. The results are displayed in Table 3:

Table 3: Panel Unit Root Test Results

Variable	Levin, Lin and Chu t	ADF-Fisher Chi-square	Philips-Perron-Fisher Chi-square	H0 (Majority)	Stationary
LLNGE	-0.72 [0.23]	5.75 [0.45]	5.66 [0.46]	Accept	No
D(LLNGE)	-3.94 [0.00]	22.30 [0.00]	23.76 [0.00]	Reject	Yes
LGRO	-0.52 [0.32]	4.85 [0.39]	3.63 [0.61]	Accept	No
D(LGRO)	-2.78 [0.00]	10.32 [0.02]	14.73 [0.00]	Reject	Yes
LDI	-0.52 [0.41]	5.45 [0.21]	7.52 [0.36]	Accept	No
D(LDI)	-3.77 [0.00]	37.40 [0.00]	36.83 [0.00]	Reject	Yes
LPGR	0.17 [0.38]	2,62 [0.49]	3.17 [0.37]	Accept	No
D(LPGR)	-3.11 [0.00]	13.73 [0.01]	11.82 [0.00]	Reject	Yes
LEX	-0.97 [0.16]	1.80 [0.93]	1.50 [0.95]	Accept	No
D(LEX)	-4.40 [0.00]	11.94 [0.06]	17.93 [0.00]	Reject	Yes

LDI = logarithm of difference of incomes, LEX = logarithm of bilateral exchange rate, LGRO = logarithm of economic growth, LLNGE = logarithm of liquefied natural gas exports of the Russian Federation to East Asia, LPGR = logarithm of population growth.

Note: Numbers in brackets indicate p-values.

Source: Authors' compilation.

The p-values shown in Table 3 prove that all the series are non-stationary at levels and stationary at their first difference, which means for the integration at I (1).

Based on the results of the panel unit root tests, we conducted the second preliminary test, which is the Pedroni panel co-integration test to discover whether there is any long-run equilibrium nexus between the series of our model. The results are displayed in Table 4:

Table 4: Pedroni Panel Co-integration Test Results

	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-statistic	0.26	0.52	–0.19	0.62
Panel rho-statistic	0.62	0.57	0.77	0.43
Panel PP-statistic	–2.32*	0.00	–2.27*	0.00
Panel ADF-statistic	–3.66*	0.00	–2.12*	0.04
Group rho-statistic	1.32	0.66	–	–
Group PP-statistic	–3.19*	0.00	–	–
Group ADF-statistic	–5.11*	0.00	–	–

ADF = Augmented Dickey-Fuller, PP = Philips-Perron.

Note: (*) shows statistical significance at the 5% level.

Source: Authors' compilation.

The probability of all the panel, group, and weighted statistics express that six of the 11 statistics are less than 0.05, and hence, the majority of the tests can reject the H0 of no co-integration at the 5% significance level. In other words, the results reveal evidence of a long-run relationship between our variables.

The existence of a long-run linkage between our variables lets us employ the co-integrating panel model. We selected one of the most popular estimators of this kind of panel data model, namely FMOLS to analyze the Russian Federation–Asia Pacific gas export pattern in the gravity theory framework. The estimation findings are represented in Table 5:

Table 5: Fully Modified OLS Estimation Results

Dependent Variable	Regressors	Coefficient	t-statistic	p-Value
LNG exports (LLNGE)	Difference in Income (LDI)	–3.74	–13.09	0.00
	Population growth (LPGR)	3.43	5.15	0.04
	Economic growth (LGRO)	6.16	15.43	0.01
	Exchange rate (LEX)	2.21	18.82	0.00
	Sanctions (SANC)	3.11	19.43	0.00
	Distance (DIS)	–7.03	31,27	0.03

LLNGE = logarithm of liquefied natural gas exports of the Russian Federation to East Asia, LNG = liquefied natural gas, OLS = ordinary least squares.

Source: Authors' compilation from Eviews 9.0.

According to the coefficients reported in Table 5, there are six major results.

First, economic growth is found to be highly significant and positive, indicating that a 1% increase in economic growth of the selected East Asian economies leads to increase of Russian Federation gas export flows to this region by nearly 6.16%.

Second, the impact of difference between per capita incomes on Russian Federation gas exports to East Asia is statistically significant and negative, supporting the Linder Hypothesis (the more two countries are similar in income, the more they might trade).

Third, the effect of population growth is found to be positive and statistically significant. Russian Federation gas exports to East Asia increase by approximately 3.43% for every 1% increase in the region's population. This result is in line with Kurniawan and Managi (2018), who showed a positive relationship between population and trade flows.

Fourth, we observe that bilateral exchange rate has a positive sign which means that a 1% depreciation of the Asia-Pacific nations' currencies against the ruble will accelerate LNG export volumes by about 2.21%. When the yuan, yen, and won are depreciating, although their import cost will increase, in domestic currency the LNG will be more expensive; on the other hand, the export of PRC, Japan, and Republic of Korea final products will be more competitive. These three countries are among the largest exporters of final products and this will boost their exports. Therefore, they will have more demand for energy and thus will import more LNG from other countries, including the Russian Federation.

Fifth, the impact of the time-invariant factor (the imposed sanctions by the West since 2014 against the Russian Federation) is found to be positive and statistically significant. This means that the sanctions were not a barrier to LNG exports to the Asian nations and helped the Russian Federation to pivot trade from the West to the East.

Sixth, we found that the negative nexus between geographical distance and LNG trade flows between the Russian Federation and the selected East Asian economies. Any increase in geographical distance as a proxy for transportation cost lowers Russian Federation LNG exports.

6. CONCLUDING REMARKS AND POLICY IMPLICATIONS

This study was an empirical attempt to explore the Russian Federation LNG export pattern among the world's three largest importers, that is, the PRC, Japan, and the Republic of Korea. Importing LNG can improve energy security in these three nations through diversifying the variety, balance, and disparity of their energy basket, lowering dependency on crude oil imports, providing a better energy source for generating electricity, and controlling climate change mitigation.

To conduct our research, we employed the gravity theory framework and the econometric approach, namely the co-integrating panel model. The findings proved that Russian Federation gas exports to East Asia follow the Linder hypothesis, denoting that the latter imports LNG more if both regions are similar in terms of factor endowment. This finding contrasts with Rasoulinezhad and Jabalameli (2018), who found that Russian Federation export patterns in manufactured goods and raw material commodities are based on the H0 hypothesis.

Our study revealed that economic growth is a positive influencing factor on Russian Federation LNG exports to this region. A bigger economic growth or production level expands demand and East Asian LNG consumption. The result of the positive relationship between economic growth and energy demand is in line with Saidi and Hammami (2015) and Rasoulilnezhad (2019), while some scholars such as Karanfil (2009) did not find any positive relationship between these two variables.

Additionally, we found that a depreciation of the Japanese yen, PRC yuan, and Republic of Korea won against the Russian Federation ruble will accelerate LNG export volume. This result is similar to Arize's 1998 finding that proved the negative relationship between exchange rate and import flows, while our result is in contrast with Chaudhary, Hashmi, and Khan (2016), who did not find any relationship between these two variables in short run.

Our findings also indicate that the 2014 imposition of sanctions by the West against the Russian Federation increased the latter's LNG exports to East Asia. This finding is based on a Russian Federation "Pivot to Asia", which was delineated by scholars such as Yennie-Lindgren (2018). In other words, as Nasre Esfahani and Rasoulinezhad (2017) argued, sanctions have led the Russian Federation to conduct an economic policy of Asianization and de-Europeanization.

The positive link between population growth and East Asian LNG imports from the Russian Federation was depicted by the results. Russian Federation gas exports to East Asia increase by approximately 3.43% given a 1% increase in regional population growth. This is in line with Brakman and Marrewijk (2013), who found a causal relationship between population and trade flows in different nations. On the one hand, a higher level of population growth means a higher need for commodities, which leads to higher trade flows. On the other hand, as Yuan and Guanghua (2015) expressed, many countries adopt a policy geared toward imports to increase their level of urbanization.

In addition, we proved a negative relationship between geographical distance and Russian Federation LNG exports to East Asia, meaning that any increase in geographical distance leads to increased transportation costs, which has been always considered as an obstacle for international trade.

The Russian Federation trade pivot to the East and LNG consumption growth in the Asia-Pacific region improve the issue of energy insecurity in the region. Here we can recommend some policies such as establishing a natural gas trading hub. This is consistent with Shi (2016), who documented how gas trading hubs were developed in the US in 1980s, UK in 1990s, and in the European Union in the 2000s. Similar policy measures were suggested by Tong et al. (2014), who expressed that any gas trading hub can set regional benchmark prices, which can be a favorable strategy for the Asia and Pacific region. Establishment of a gas hub will positively contribute to accessibility and affordability of LNG and will improve regional energy security. One of the main questions for establishing a gas hub pertains to liquidity, since it constitutes one of the most important requirements for successful LNG trading. In the case of Asia and the Pacific, the market can be improved by standardization of traded contract terms and conditions. Furthermore, developing financial markets (physical and futures) can be a key for providing a liquidity hub in this region. Additionally, import diversification can reduce energy insecurity. This policy is in line with Shaikh et al. (2016), who showed a positive relationship between diversification of suppliers and LNG supply security. The need for energy supplier diversification has been proved by Taghizadeh-Hesary et al. (2017) for Japan, which flourishes under self-dependency and energy security.

Another important point is pricing power in the LNG regional market. Any attempt to control pricing may create cartels; in the future, there would likely be a sellers' or buyers' cartel in this market. However, due to the reduced trade volume of LNG compared with natural gas, this cannot happen in the near future. Currently, there is the Gas Exporting Countries Forum, which includes 11 global leading natural gas producers, that has not been efficient. By developing its outputs, we can predict seeing an LNG cartel in the future.

Analyzing LNG trade patterns from the Russian Federation into the East Asian economies by using various variables shows how these variables are not alone. Many other variables such as LNG price, geographical border, and financial stability can affect Russian Federation LNG exports to this region. We recommend that future studies use some new variables and patterns as well.

REFERENCES

Arize, A. C. 1998. The Long-Run Relationship between Import Flows and Real Exchange-Rate Volatility: The Experience of Eight European Economies. *International Review of Economics and Finance* 7(4): 417–435.

Aung, T. S., B. Saboori, and E. Rasoulinezhad. 2017. Economic Growth and Environmental Pollution in Myanmar: An Analysis of Environmental Kuznets Curve. *Environmental Science and Pollution Research* 24(25): 20487–20501.

Balitskiy, S., Y. Bilan, W. Strielkowski, and D. Streimikiene. 2016. Energy Efficiency and Natural Gas Consumption in the Context of Economic Development in the European Union. *Renewable and Sustainable Energy Reviews* 55: 156–168.

Barreto, R. A. 2018. Fossil Fuels, Alternative Energy and Economic Growth. *Economic Modelling* 75: 196–220.

Bielecki, J. 2002. Energy Security: Is the Wolf at the Door? *Quarterly Review of Economics and Finance* 42: 235–250.

Brakman, S., and C. Marrewijk. 2013. Lumpy Countries, Urbanization, and Trade. *Journal of International Economics* 89(1): 252–261.

Cabalu, H., and C. Manuhutu. 2009. Vulnerability of Natural Gas Supply in the Asian Gas Market. *Economic Analysis and Policy* 39(2): 255–270.

Calder, K. E. 2006. Coping with Energy Insecurity: China's Response in Global Perspective. *East Asia* 23(3), 49–66.

Charp, A., and Jewell, J. 2014. The Concept of Energy Security: Beyond the Four As. *Energy Policy* 75: 415–421.

Chaudhary, G., S. Haider Hashmi, and M. Asif Khan. 2016. Exchange Rate and Foreign Trade: A Comparative Study of Major South Asian and South-East Asian Countries. *Procedia – Social and Behavioral Sciences* 230: 85–93.

Chen, Z., H. An, X. Gao, H. Li, and X. Hao. 2016. Competition Pattern of the Global Liquefied Natural Gas Trade by Network Analysis. *Journal of Natural Gas Science and Engineering* 33: 769–776.

Dhameliya, H., and P. Agrawal. 2016. LNG Cryogenic Energy Utilization. *Energy Procedia* 90: 660–665.

Fadiran, G., A. Adebusuyi, and D. Fadiran. 2019. Natural Gas Consumption and Economic Growth: Evidence from Selected Natural Gas Vehicle Markets in Europe. *Energy* 169: 467–477.

Fortescue, S. 2016. Russia's Economic Prospects in the Asia Pacific Region, *Journal of Eurasian Studies* 7(1): 49–59.

Gielen, D., F. Boshell, D. Saygin, M. D. Bazilian, N. Wagner, and R. Gorini. 2019. The Role of Renewable Energy in Global Energy Transformation. *Energy Strategy Reviews* 24: 38–50.

Henderson, J. 2011. The Pricing Debate over Russian Gas Exports to China. Working Paper NG56, Oxford Institute for Energy Studies.

Henderson, J., and J. Stern. 2014. The Potential Impact on Asia Gas Markets of Russia's Eastern Gas Strategy. Oxford Energy Comment, Oxford Institute for Energy Studies. URL: https://www.oxfordenergy.org/wpcms/wp-content/uploads/2014/02/The-Potential-Impact-on-Asia-Gas-Markets-of-Russias-Eastern-Gas-Strategy-GPC2-.pdf (accessed 1 June 2019).

Holzer, K. K., J. R. Muirhead, M. S. Minton, K. J. Carney, A. Miller, and G. M. Ruiz. 2017. Potential effects of LNG trade shift on transfer of ballast water and biota by ships, *Science of The Total Environment*, 580, 1470–1474.

IEA. 2018. Gas 2018: Analysis and Forecasts to 2013. Paris: International Energy Agency. https://www.iea.org/gas2018/ (accessed on 13 March 2019).

IRENA. 2018. Global Energy Transformation: A Roadmap to 2050. Abu Dhabi: International Renewable Energy Agency. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Apr/IRENA_Report_GET_2018.pdf.

Karanfil, F. 2009. How Many Times Again Will We Examine the Energy-Income Nexus Using a Limited Range of Traditional Econometric Tools? *Energy Policy* 36: 3019–3025.

Kim, Y. 2017. Asian LNG Market Changes Under Low Oil Prices: Prospects for Trading Hubs and a New Price Index. *Geosystem Engineering* 20(3): 129–141.

Kurniawan, R., and S. Managi. 2018. Coal Consumption, Urbanization, and Trade Openness Linkage in Indonesia. *Energy Policy* 121: 576–583.

Matsumoto, K., and K. Andriosopoulos. 2016. Energy Security in East Asia under Climate Mitigation Scenarios in the 21st Century. *Omega* 59 (Part A): 60–71.

Moshin, M., P. Zhou, N. Iqbal, and S. A. A. Shah. 2018. Assessing Oil Supply Security of South Asia. *Energy* 155(C): 438–447.

Nasre Esfahani, M., and E. Rasoulinezhad. 2016. Will There Be New CO_2 Emitters in the Future? Evidence of Long-Run Panel Co-Integration for N-11 Countries *International Journal of Energy Economics and Policy* 6(3): 463–470.

———. 2017. Iran's Trade Policy of Asianization and De-Europeanization Under Sanctions. *Journal of Economic Studies* 44(4): 552–567.

Raj, R., S. Ghandehariun, A. Kumar, J. Geng, M. Linwei. 2016. A Techno-Economic Study of Shipping LNG to the Asia-Pacific from Western Canada by LNG Carrier. *Journal of Natural Gas Science and Engineering* 34: 979–992.

Ralph, N., and L. Hancock. 2019. Energy Security, Transnational Politics, and Renewable Electricity Exports in Australia and Southeast Asia. *Energy Research and Social Science* 49: 233–240.

Rasoulinezhad, E. 2017. China's Foreign Trade Policy with OPEC Member Countries. *Journal of Chinese Economic and Foreign Trade Studies* 10(1): 61–81.

———. 2019. Analyzing Energy Export Patterns from the Commonwealth of Independent States to China: New Evidence from Gravity Trade Theory. *The Chinese Economy* 52(3), 279–294.

Rasul, G. 2014. Food, Water, and Energy Security in South Asia: A Nexus Perspective from the Hindu Kush Himalayan Region. *Environmental Science and Policy* 39: 35–48.

Saboori, B., E. Rasoulinezhad, and J. Sung. 2017. The Nexus of Oil Consumption, CO_2 Emissions and Economic Growth in China, Japan and South Korea. *Environmental Science and Pollution Research* 24(1): 1–20.

Saidi, K., and S. Hammami. 2015. The impact of CO_2 emissions and economic growth on energy consumption in 58 countries. *Energy Reports*, 1, 62–70.

Shibasaki, R., T. Usami, M. Furuichi, H. Teranishi, and H. Kato. 2018. How Do the New Shipping Routes Affect Asian Liquefied Natural Gas Markets and Economy? Case of the Northern Sea Route and Panama Canal Expansion. *Maritime Policy & Management* 45(4): 543–566.

Sovacool, B. K. 2013. Assessing Energy Security Performance in the Asia Pacific, 1990–2010. *Renewable and Sustainable Energy Reviews* 17: 228–247.

Stegen, K. 2015. Understanding China's Global Energy Strategy. *International Journal of Emerging Markets* 10(2): 194–208.

Stirling, A. 2010. Multicriteria Diversity Analysis: A Novel Heuristic Framework for Appraising Energy Portfolios. *Energy Policy* 38: 1622–1634.

Taghizadeh-Hesary, F., E. Rasoulinezhad, N. Yoshino. 2019. Energy and Food Security: Linkages through Price Volatility. *Energy Policy* 128: 796–806, doi.org/10.1016/j.enpol.2018.12.043.

Taghizadeh-Hesary, F., N. Yoshino, and E. Rasoulinezhad, E. 2017. Impact of the Fukushima Nuclear Disaster on the Oil-Consuming Sectors of Japan. *Journal of Comparative Asian Development* 16(2): 113–134.

Taghizadeh-Hesary, F., N. Yoshino, Y. Chang, and A. Rillo. 2019. Introductory Remarks and Preface. In *Achieving Energy Security in Asia: Diversification, Integration and Policy Implications*, edited by F. Taghizadeh-Hesary, N. Yoshino, Y. Chang, A. Rillo. Singapore: World Scientific.

Taniguchi, M., N. Masuhara, and K. Burnett. 2017. Water, Energy, and Food Security in the Asia Pacific Region. *Journal of Hydrology: Regional Studies* 11: 9–19.

Thomson, H., J. J. Carbett, and J. J. Winebrake. 2015. Natural Gas as a Marine Fuel. *Energy Policy* 87: 153–167.

Tong, X., J. Zheng, and B. Fang. 2014. Strategic Analysis on Establishing a Natural Gas Trading Hub in China. *Natural Gas Industry B* 1(2): 210–220.

Tongsopit, S., N. Kittner, Y. Chang, A. Aksornkij, and W. Wangjiraniran. 2016. Energy Security in ASEAN: A Quantitative Approach for Sustainable Energy Policy. *Energy Policy* 90: 60–72.

Varahrami, V., and M. S. Haghighat. 2018. The Assessment of Liquefied Natural Gas Demand Reversibility in Selected OECD Countries. *Energy Reports* 4: 370–375.

Withers, M. R., et al. 2014. Economic and Environmental Assessment of Liquefied Natural Gas as a Supplemental Aircraft Fuel. *Progress in Aerospace Sciences* 66: 17–36.

Wood, D. A. 2012. A Review and Outlook for the Global LNG Trade. *Journal of Natural Gas Science and Engineering* 9: 16–27.

Yao, L., and Y. Chang. 2014. Energy Security in China: A Quantitative Analysis and Policy Implications. *Energy Policy* 67: 595–604.

Yennie-Lindgren, W. 2018. New Dynamics in Japan–Russia Energy Relations 2011–2017. *Journal of Eurasian Studies* 9(2): 152–162.

Yuan, Z., and W. Guanghua. 2015. International Trade and the Urbanization of Developing Countries: Evidence from Asia. *Social Sciences in China* 36(2): 186–205.

Zhang, H., W. Xi, Q. Ji, and Q. Zhang. 2018. Exploring the Driving Factors of Global LNG Trade Flows Using Gravity Modeling. *Journal of Cleaner Production* 172: 508–515.

Zou, C., Zhao, Q., Zhang, G., and Xiong, B. 2016. Energy revolution: from a fossil energy era to a new energy era. *Natural Gas Industry B*. 3 (1), 1–11.