Research Paper

Assessment and Evaluation of Energy Security in Russia based on Factor Analysis Model*

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Abstract

One of the most important issues in the world economy is the concept of energy security and the study of its various dimensions in different countries. Energy security is of great importance for Russia as one of the largest oil and gas producing countries in Northern Asia and the world. This study seeks to measure various aspects of energy security in Russia using Factor Analysis Model. Results indicate a high degree of interdependence between the two variables of economic growth and energy intensity in Russia. The results of the EFA also show that the two factors, including the general factor and the investment science factor, can explain about 85% of the variance of the observed variables. Moreover, the results of the Russian invasion of Ukraine and its impact on energy security demonstrate the need to separate the short-term effects of the conflict on energy security from the long-term effects. Russia suffers from energy stickiness due to its economic and political structure and will lag behind the West in the medium- and long-term renewable energy replacement program.

Keywords: Energy Intensity, Exploratory Factor Analysis, Final Energy Consumption, Gross Domestic Product, Primary Energy Supply, Ukraine Conflict

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1. Introduction

Energy policy is one of the most complex processes and challenges in the modern world; energy security is both an obstacle and a basic requirement for socioeconomic development and sustainable development (Kanwal et al., 2022; Podbregar, Šimić, Radovanović, Filipović & Šprajc, 2020; Zhang, Papageorgiou & Fraga, 2012). The rapid increase in global energy demand has led to concerns about energy security (Lee & Wange, 2022). Energy plays an important role in shaping the concept of security in socioeconomic and political contexts (Seker, 2019), and as discussed by Schaffer and Levis (2022), energy transition relies on political decisions made by sovereign nation-states. That is, historically, governments have constantly struggled over resources that represent wealth and power (Seker, 2019). According to Kucharski & Unesaki (2015), increasing demand and competition for energy resources, along with fears of possible resource depletion, high prices, and climate change impacts, are at the heart of energy security. Issues related to energy security and climate change have threatened the reliability of current hydrocarbon energy systems (Giarola & Bezzo, 2015); this is especially true for Russia, which is highly dependent on hydrocarbon exports. Experts and policymakers have considered oil supply security to be the same as energy security. Carollo (2012) noted that despite many debates about the oil age, this fuel is still the most important source of primary energy and is significantly different from other fuels. Statistics from the International Energy Agency also reveal that oil ranks first among primary energies, followed by coal and natural gas.

According to the World Energy Outlook published by the International Energy Agency (2021, p. 15), despite all the progress in renewable energy and electric movement, the year 2021 has seen a major return in the use of coal and oil, mainly because the second annual increase in carbon dioxide emissions in the history of earth, and the high share of oil in demand is expected to remain with little change until 2030. According to the same source (World Energy Outlook, 2021, p. 28), oil demand will decline for the first time in the 2030s under the stated policy scenario, driven by weaker growth in petrochemicals and faster declines in other sectors. Recently, policymakers have included natural gas supply in the definition of the energy basket. The safety aspects of natural gas are similar to petroleum, but not the same. Compared to crude oil imports, natural gas imports have a smaller share in most importing countries, which is due to the fact that it is cheaper to transport liquid crude oil and crude oil products than natural gas (Speight, 2020). Rutland (2008) argued that oil and gas are key to Russia's return to international glory, which explains the reason for which it is nowadays common to refer to Russia as an "energy superpower". Tynkkynen (2019, p. 22) refers to the energy superpower as a power that can influence the political decisions of other countries through energy exports, build dependence through energy infrastructure, and derive economic gains from energy trade. Russia is the world's second largest producer of fossil fuels, producing 701.7 billion cubic meters of natural gas, according to Statista (2022a, Jun. 29). In addition, Russia has over 107 billion barrels of proven reserves of oil—6.2% of the world's total oil reserves—most of which are located in Siberia, and produced 536.4 million metric tones of oil in 2021 (Statista, 2021, Jul. 21; NS Energy, 2022b, Jun. 29; NS Energy, 2020, Nov. 4). Thus, the country's economy is largely focused on hydrocarbons; oil and gas revenues—including exports—account for 36% of Russia's state budget revenues (US Energy Information Administration, 2017, Nov. 14). It is important to note that Russia is not as cursed as

Saudi Arabia, Turkmenistan, and Venezuela, but it is far more cursed than the United States and Norway, which are also major energy players. Thus, from an economic point of view, Russia's dependence is a combination of the two groups of oil and gas producers mentioned above (Tynkkynen, 2019, p. 2). Russia's energy strategy aims to maximize the use of domestic energy resources and exploit the potential of the energy sector to sustain economic growth and guide the country's strategic development. The goal of this strategy is also to reduce the country's energy intensity by 56% by 2030 (International Energy Agency, 2021, Aug. 24). The way energy security is defined is contextual and dynamic, so that the increasing emphasis on aspects such as environmental sustainability and energy efficiency has broadened the scope of energy security (Ang, Choong & Ng, 2015). The International Energy Agency (2019, Dec. 2) refers to energy security as the uninterrupted availability of an affordable energy source. Energy security has several aspects. Long-term energy security results primarily from economic development and timely investment in energy supply in response to environmental needs, while short-term energy security addresses the energy system ability to respond quickly to rapid changes in the balance of supply and demand.

Energy security research has now shifted from a classical approach to an interdisciplinary field. This is because many aspects must be considered in the assessment of its various components. Therefore, security assessments should be based on scientific models to track the changing geopolitical scenarios and provide accurate information and quantitative indicators to policymakers (Jakstas, 2020; Bompard et al., 2017). Climate change, globalization, and the uncertain future of fossil fuels have added new dimensions such as sustainability, energy efficiency, reduced greenhouse gas emissions, and access to energy services (energy poverty). Thus, energy security is linked to other environmental, social, political, and security issues (Jakstas, 2020). Cherp et al. (2012, p. 327) broadly define energy security as robustness (resource adequacy, infrastructure reliability, and stable and cost-effective prices), sovereignty (protection from potential threats from external factors), and resilience (ability to withstand various disruptions) of the energy system. Sevacool, Mukherjee, Drupady & D'Agostino (2012) presented a national energy security indicator that measures energy security in five dimensions related to availability, cost-effectiveness, technology development, sustainability, and regulation. Li, Shi and Yao (2016) assessed the energy security of resource-poor countries using the three dimensions of vulnerability, efficiency, and sustainability. Martchamadol and Kumar (2013) used the aggregated energy security performance indicator (AESPI) developed with 25 individual indicators representing social, economic, and environmental aspects. Narula and Reddy (2016) and Radovanovic, Filipović, and Pavlović (2017) proposed the concept of sustainable energy security, based on the premise that existing methods for measuring energy security focus heavily on energy reliability, regardless of environmental performance and social dimensions. In their approach, a hierarchical structure was proposed, and the energy system was divided into the subsystems of supply, conversion, distribution, and demand. Each subsystem consists of components that use quantitative indicators to score off four dimensions of sustainable energy security including availability, economy, efficiency, and (environmental) acceptability. Azzuni and Breyer (2020) developed an accurate numerical method for formulating an energy security index that is globally comprehensive, and also applicable to all countries at the national scale. This index consists of 15 dimensions, 50 parameters, and 78 indicators. The authors claimed that some alternative indicators do not seem to be directly related to energy security, but are important because of the energy security perspective. In addition, since this analytical framework explores the concept of energy security at different levels (dimensions, parameters, indicators), appropriate indicators are required for each parameter, as well as a logical correlation between the parameters and dimensions. Finally, as argued by Gasser (2020), the use of energy security indicators has expanded in recent years because index-based approaches are particularly well-suited for multidimensional modeling and country comparison. Indicators are also an effective communication tool for policymakers. Narula and Reddy (2015) claimed that different indicators for different countries yield different values that are sometimes contradictory, and that small changes in values and weights can change a country's relative ranking. In addition, an index may be inaccurate, and cross-index scores may add value. Thus, there are significant differences among studies in how to create and construct an energy security index, and these differences pose a problem when comparing study results (Ang et al., 2015). In this research, the model of Azzuni and Breyer (2020) is used because it is comprehensive and provides the opportunity to access more indicators and have more options.

2. Literature Review

Filipović, Radovanović and Golušin (2018) used exploratory data analysis to examine the political and macroeconomic aspects of energy security. The results indicated that GDP per capita, country risk, carbon intensity, energy intensity, final energy consumption per capita, and electricity price had a significant impact on energy conservation, while renewable energy sources had the smallest share in total energy demand and energy dependence. Li et al. (2016) evaluated energy security in a three-level framework using principal component analysis. Their study indicated that the three dimensions of vulnerability, efficiency, and sustainability were essential for resource-poor economies, including Singapore, South Korea, Japan, and Taiwan. Allemzero et al. (2020) assessed energy security in Africa based on the multilevel mixture factor analysis using thirteen indicators. Their research suggested that there was a pattern of energy insecurity as well as vulnerabilities among selected countries on the African continent, as most of them rely heavily on imports for domestic consumption. Markovska et al. (2016) studied the main challenges of energy security in the 21st century, which included decarbonization of the global economy, strengthening energy efficiency and energy storage in buildings, advancing energy technologies going along to a system based on variable renewable energy, electrification of some industrial and transportation processes, liberalization and development of energy markets, smarter design of communities and cities, diversification of energy sources, and building more biorefineries. Lee, Xing and Li (2022) used the dynamic panel threshold approach to analyze the impact of energy security on economic inequality. Their study revealed that energy security tends to worsen income distribution in the early stages of economic development, while it improves income distribution when a certain level of development is reached. As indicated by Taghizadeh-Hesary, Zakeri, Yoshino and Khan (2022), energy security plays an important role in poverty reduction.

Chung, Kim, Moon, Lim and Yun (2017) developed a conceptual framework for energy security assessment in South

Korea. They examined fuel options for electricity generation, including coal, nuclear, natural gas, oil, and renewables. The criteria used in this framework included supplier reliability, economics of electricity generation, environmental compatibility, and technological complementarity. Nawaz and Alvi (2018) studied energy security in terms of environmental and socioeconomic sustainability in Pakistan. In their study, Johansson cointegration and Granger causality model based on vector correction model were used. The authors concluded that policymakers should minimize their dependence on energy imports and increase energy efficiency to achieve long-term energy security towards socio-economic and environmental sustainability. Mohtashami, Ebrahimi Salari and Mahdavi Adeli (1394 [2015 A.D.]) assessed the energy security of member countries of the Organization for Economic Cooperation and Development (OECD). To measure it, they used a composite index based on a seven-step methodology. The final results of the ranking indicated that the United States, in particular, paid attention to various aspects of energy security, and managed to take the first place in this group in energy security, with a significant difference from other countries. The results of this study are consistent with the study of Mara, Nate, Stavytskyy and Kharlamova (2022), in which they used a regression model to test the crucial factors of socioeconomic development that affect energy security indicators. The results revealed that the significant correlation of economic and energy security is only for the U.S., while the rest of the countries under study have weak or non-significant correlations among the economic, energy, and security threat indices. The development of strategic oil reserves, the diversification of energy supply, the high level of technology, and good governance are among the main factors that have led to this position. Moein al-Din and Entezar al-Mahdi (1389 [2010 A.D.])

examined Russia's energy security and energy diplomacy. Their results suggested that Russia, one of the world's major energy producers, has pursued the following policies: diversification of supply sources, diversification of supply zones, development of energy transmission infrastructure, active participation in international energy markets, international financial and energy markets, and international energy organizations to attract foreign investment. Finally, different studies have used different energy security measures, tools, and methods. As a result, the measures used in this paper quantify part of energy security in Russia. For a comprehensive measurement, it is necessary to examine the various dimensions, including environmental, economic, political, and even cultural.

3. Research Methodology

In order to assess energy intensity in Russia, two measures of final energy consumption and primary energy supply were used, as well as the correlation between energy consumption and GDP. Then, Pearson's correlation analysis and factor analysis were used to study various aspects of energy security in Russia. The main advantage of statistical correlation analysis is that it evaluates the intensity of the relationship between two economic variables based on the available real data. In other words, it calculates the degree of sensitivity of one variable to another economic variable based on the trend of the last year. On the other hand, the factor analysis approach, as a method known in the field of quantitative research methodology, discovers and limits the existing layers hidden in the effect of different explanatory variables on the dependent variable, enabling the researcher to find a network between different dimensions of the concept. The variables in this study are quantitative and time series type. To explain energy security through exploratory factor analysis, thirteen indicators were identified using the framework of Azzuni and Breyer (2020), and data for Russia were obtained from different databases depending on the level of access until 2019 (and 2022). Data were analyzed using the Excel program and SPSS software version 26. The calculation steps are listed in the results section.

4. Research Findings

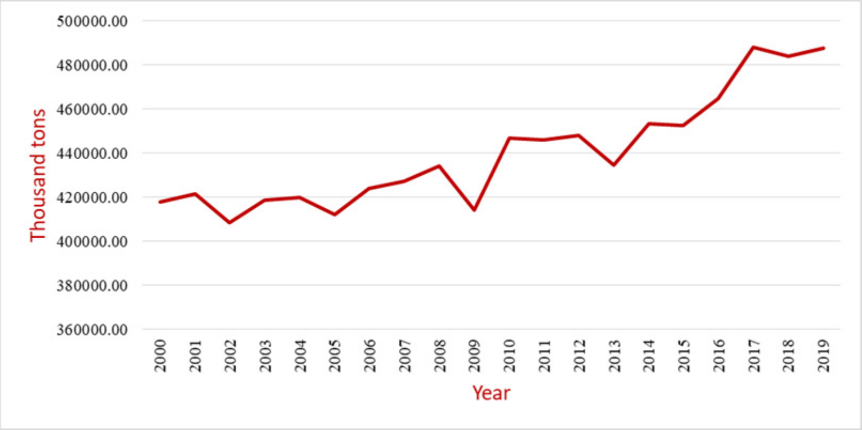
4. 1. Demand Management and Energy Security in Russia

According to the definition of the European Environment Agency (2013, Nov. 12), final energy consumption refers to all energy supplied to the final consumer (oil, natural gas, coal, nuclear, hydro, renewable energy), which includes all energy consumption and is usually subdivided into the final consumption sectors of industry, transport, households, services, and agriculture. As stated by the European Environmental Agency (2013, Nov. 12), this model is owned by the International Energy Agency and covers the period from 2004 to 2030. "The energy sector is a major cause of environmental concerns such as climate change, air pollution and water stress", the EU Environment Agency said, explaining its choice. "Final energy consumption data help estimate the environmental impact of energy use. The nature and extent of energy-related environmental impacts depend on both the energy sources (and their use) and the total amount of energy consumed. One way to reduce energy-related environmental impacts is to use less energy. This can be done by using less energy for related activities (such as heating, personal mobility, or freight transportation) or by using energy more efficiently (resulting in less energy consumed per unit of demand), or a combination of the two.

This indicator helps evaluate the achievement of policy goals related to energy consumption and efficiency. It can also be used to identify appropriate policy options to make the energy sector more sustainable, address climate change, and reduce water stress and air pollution."

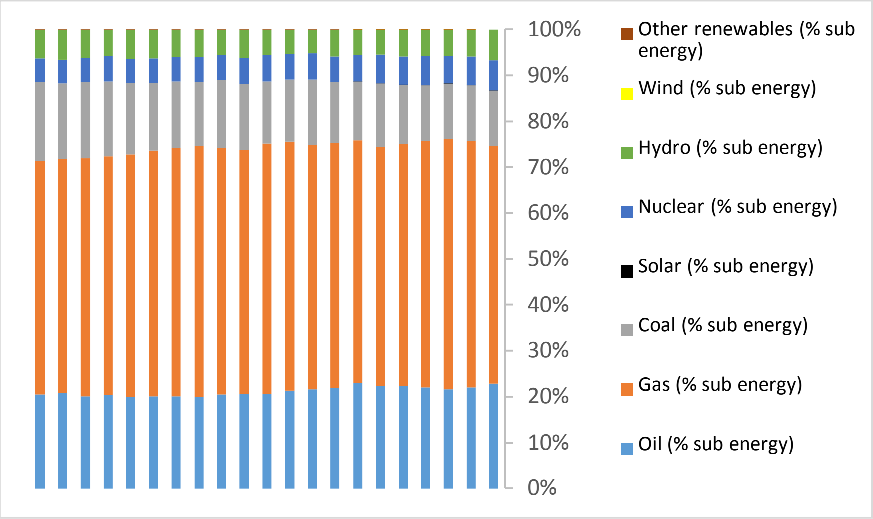
Figure 1 indicates that final energy consumption in Russia has always increased, especially since 2013. According to the International Energy Agency, accessed on (2021, Aug. 24), Russia's energy strategy is to reduce energy intensity by 56% by 2030. In 2020, natural gas accounted for more than 52% of Russia's primary energy consumption, a slight decrease from the previous year. Oil accounted for the second largest share of the country's primary energy consumption in 2020, nearly 22.6%. Renewable energy accounted for only 0.14% in 2020 (Statista, 2022c, Jun. 29). Figure 2 illustrates the share of energy consumption in Russia by energy source. In general, the share of primary energy consumption in its various forms in Russia has not changed significantly in the past two decades. According to Mitrova and Melnikov (2019), Russia ranks fourth in the world in terms of primary energy consumption and carbon dioxide emissions. At the same time, de-carbonization of the energy sector is not in sight; energy intensity is highly relative to GDP and is supported by relatively low energy prices and high capital costs, as well as massive fossil fuel subsidies (Gritsenko & Salonen, 2021; Mitrova & Melnikov, 2019). In addition, solar and wind energy are expected to account for no more than 1% of Russia's energy balance by 2040. The challenge for Russia in the coming years is to develop a new strategy to develop its energy sector, which will enter turbulent territory without any impact on the climate change agenda due to increasing global competition, technological isolation, and financial constraints (Mitrova & Melnikov, 2019).

Figure 1. Final Energy Consumption in Russia



Source: Authors Compilation Using NationaMaster Data, 2022

Figure 2. Russia's energy consumption by source (percentage) by 2020



Source: Authors Compilation using Ritchie and Roser (OurWorldInData.org/energy), 2020 and Statistical Review of World Energy (2020)

The Quantitative Assessment of Energy Security Working Group (2011, p. 13) identified demand-side management as one of the key components of energy security and provided the following two yardsticks to measure it. Both criteria are used to assess energy intensity. Energy intensity is a measure often used to assess energy efficiency in a given economy. Its numerical value is calculated based on the ratio of energy consumption (or energy supply) to GDP, and indicates how well an economy converts energy into money. The unit is usually Joule per Dollar, but other equivalent measures also exist. The lower the calculated ratio, i.e., the lower the energy intensity, the better, which indicates a more efficient allocation of energy resources to create more wealth and quality of life (Martinez, Ebenhack, & Wagner, 2019).

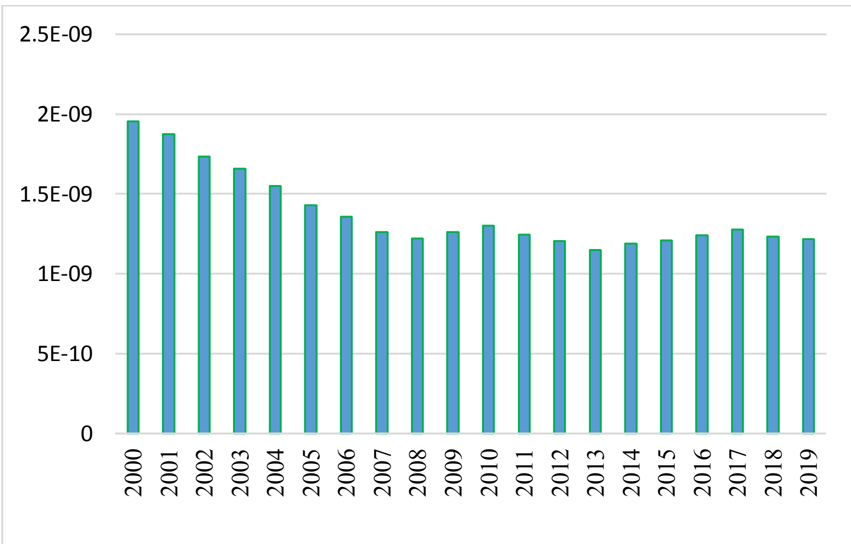
a) TFEC/GDP ratio = (TFEC) / (GDP)

b) TPES/GDP ratio = (TPES) / (GDP)

a) Total Final Energy Consumption (TFEC) to GDP Ratio

The data on final energy consumption were taken from the NationMaster database (2022), based on thousands tons of oil equivalent from 2000 to 2019. GDP data, based on purchasing power parity in Dollars and base year 2017, were taken from the World Bank database (World Bank, 2022). The choice of base year is due to the elimination of inflation effects. The lower the final energy consumption per unit of GDP, the better the situation. According to the results, the index decreased from 2000 to 2013 (except 2009 and 2010), indicating an improvement in energy efficiency at the end-use level. However, from 2014 to 2019, this ratio has increased on average, indicating a deterioration of energy efficiency. It should be noted that this indicator alone is not sufficient to measure energy efficiency. According to the Organization for Economic Cooperation and Development (OECD, 2014), the energy intensity indicator is sometimes used to describe energy efficiency, which can be misleading because energy intensity depends on various elements beyond energy efficiency, such as climate, the composition of production, the outsourcing of goods produced by energy-intensive industries, etc.

Figure 3. Russia's final energy consumption based on Russia's GDP



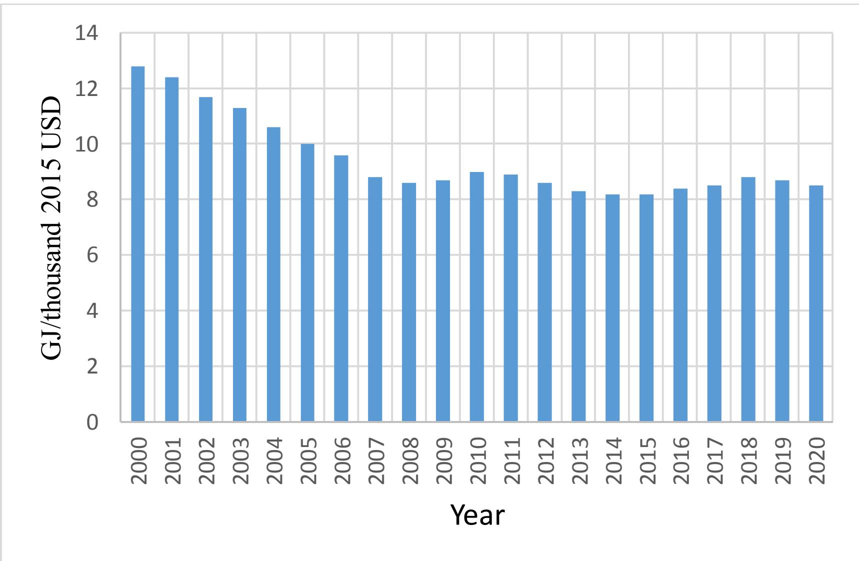
Source: Authors Compilation Based on World Bank 2022 and NationMaster, 2022

b) Total Primary Energy Supply (TPES) to GDP Ratio

This index indicates energy intensity. The data on total energy supply was taken from the International Energy Agency (2022, Jan.

12), which is calculated in gigajoules per thousand US Dollars. GDP is also calculated in purchasing power parity and in base year 2015. As illustrated in Figure 4, the trend is the same as that of the total energy consumption per unit of GDP. Yet, for a more accurate assessment of energy intensity, we will look at the trends in the GDP variables as indicators of energy economics and energy consumption, as well as the correlation between them.

Figure 4. Total Energy Supply Based on GDP in Russia

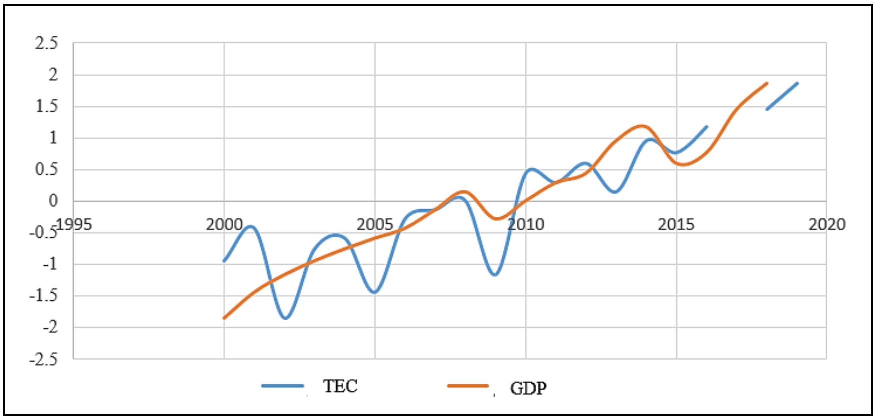


Source: Authors Compilation Based on World Bank 2022 and NationMaster, 2022

4.2. Correlation between Energy Consumption and GDP

As mentioned earlier, energy intensity is expressed as the ratio between gross domestic energy consumption and GDP. Economic growth has led to higher energy consumption, and thus a greater burden on the environment from energy production and consumption. The energy intensity indicator determines the extent to which there is a separation or independence between energy consumption and economic growth. Relative decoupling occurs when energy consumption grows more slowly than the economy (GDP), and absolute decoupling occurs when energy consumption is stable or when energy consumption decreases as GDP increases. Absolute decoupling is expected to reduce the environmental impact of energy production and consumption (European Environment Agency, 2019, May. 12). In addition, a reduction in this ratio could indicate a restructuring of the economy and a shift away from energy-intensive industries, such as iron and steel. Yet, if overseas producers adopt energy-efficient technologies, the harmful effects of this outsourcing may increase global environmental damage (OECD, 2014). As indicated in Figure 5, not only has the gap between energy consumption and GDP (economy) not widened in Russia over the past two decades, but this dependence and convergence has continued. The results of the Pearson correlation test (Table 1) also show the significance of the relationship at a level of 99% and the high intensity of the dependence between the two variables. Before performing the test, the variables were normalized and then standardized using the SPSS program, since the variables have different units of measurement. It can be said that on average over the last two decades, energy intensity not only did not decrease, but at times it even increased, especially after 2010, and in 2018 and 2019, there was little improvement and in terms of energy sustainability as one of the most important components of energy security, Russia is far from the desired state.

Figure 5. Trend of standardized variables of GDP and energy consumption in Russia from 2000 to 2019



Source: Authors' Compilation

Table 1. Correlation test between GDP and total energy consumption (Russia, 2000-2019)

		Total Energy Consumption	GDP
Total Energy Consumption	Pearson Correlation	1	.829**
	Sig. (2-tailed)		.00001
	N	19	18
GDP	Pearson Correlation	.829**	1
	Sig. (2-tailed)	.00001	
	N	18	19

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Authors' Compilation from SPSS

4.3. Russian Energy Security Exploratory Factor Analysis

In this study, exploratory factor analysis with principal component model was used as dimension reduction analysis (Costello &

Osborne, 2005; DeCoster, 1999) to find the underlying and latent variables that explain the variance of the explicit variables. According to Schumacker and Lomax (2016, p. 86), exploratory factor analysis is used to assign the number of factors needed to explain the correlation between a series of observed variables. The variance-covariance matrix or correlation matrix is used as the basis and input for the factor analysis. The variables in this study are quantitative and of the time series type. In order to explain energy security through exploratory factor analysis, thirteen indicators were identified through the framework of Azzuni & Breyer (2020) and the data for Russia were obtained from different databases according to the extent of access until 2019 (and 2022), and analyzed.

The distribution of the variables was investigated before the analysis through the Shapiro–Wilk normal distribution test (it has low sensitivity to sample size and is suitable for samples with small size). To normalize the distribution of the abnormal variables, the fractional ranking and then the inverse function were used. In addition, the variables were standardized and the missing values were replaced by the linear trend at point. In this study, the typical load factor limit of 0.5 (Mansourfar, 1387 [2008 A.D.]) was used to detect the structure of factor correlation and the relationship between latent and explicit variables. Excel and SPSS were used for the analysis.

Table 2. Variables Used in the Factor Analysis

Variable	Unit/level of Measurement	Source	Mean	Standard Deviation
energy efficiency	US Dollars Per Unit of Total Primary Energy Supply	NationMaster (2022)	4372.34	477.96
Per capita total primary energy supply	Relative variable	NationMaster (2022)	0.00000473	0.000000282
Per capita carbon dioxide emissions	Relative variable	Statistical Review of World Energy – BP (2022, Jan 28)	10.58	0.37
Total greenhouse gas emissions except in cases of land use change and forestry	MTCO2e: Metric tons of carbon dioxide equivalent	Climate Watch (CAIT) (2015, Jun. 22)	2419.13	134.43
Scientific citations	Number	Scimago Institutions Ranking. (n.d.).	52017.60	23554.44
Number of scientific articles	Number	World Bank (2022a, Jan. 20)	41019	14944
Research and development costs (percentage of GDP)	Percentage	World Bank (2022b, Jan. 20)	1.1	0.08
KOF Globalization Index (Globalization index from 1 to 100)	Percentage	Gygli, Florian, Niklas & Jan-Egbert, 2019	69.45	5.47
Human Development Index (HDI)	-	United Nations Development Program (2022)	0.77	0.04
Life expectancy index	Year	World Bank (2022c, Jan. 20)	68.69	2.18
Military expenditures (percentage of GDP)	Percentage	World Bank (2022d, Jan. 20)	3.62	0.31
Health expenditures (percentage of GDP)	Percentage	World Bank (2022e, Jan. 20)	5.08	0.27
Government expenditures on education (percentage of total government expenditures)	Percentage	World Bank (2022f, Jan. 20)	11.11	1.17

Source: Authors' Compilation from SPSS

The calculated test for sampling adequacy (KMO) (Table 3) illustrates the reasonableness and adequacy of the sampling and the attachment of the variables to each other for factor analysis (0.6). Bartlett's sphericity test was also significant at the 1% level (Sig. < 0.01). Therefore, exploratory factor analysis can be used to explain the variance of the explicit variables (13 variables in Table 2).

Table 3. Bartlett and KMO tests

Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO)		.600
Bartlett's Test of Sphericity	Approx.Chi-Square	415.788
	Df	78
	Sig.	.000001

Source: Authors' Compilation from SPSS

Based on the eigenvalues, a two-factor solution was proposed by the program (eigenvalues greater than 1). In other words, two factors with eigenvalues greater than 1 explained the variance of the values of the explicit variables. Together, these factors were able to explain 84.5% of the variance (Table 4).

Table 4. Total Explained Variance

Factor	Initial Eigenvalues			Total Variance Explained		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	8.234	63.338	63.338	6.663	51.252	51.252
2	2.764	21.261	84.599	4.335	33.347	84.599
3	.767	5.903	90.501			
4	.532	4.093	94.594			

Source: Authors' Calculation from SPSS

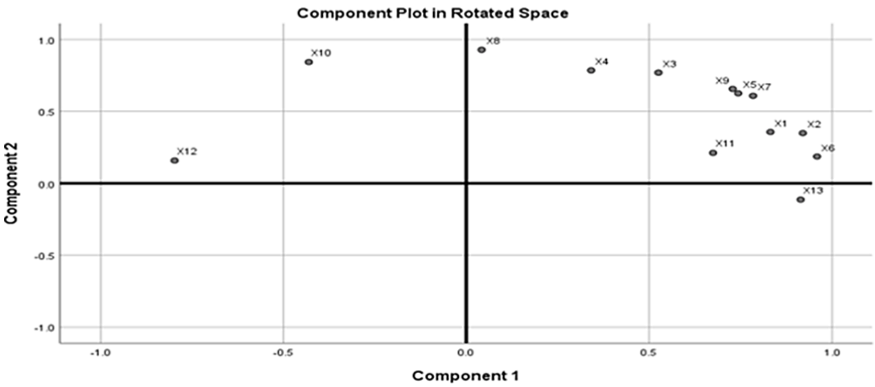
Finally, according to the results indicated in Table 5, thirteen variables were loaded on two factors as latent variables and underlying factors of variance. The extraction fraction must also be greater than 0.5. The first and second components explained 51% and 33% of the variance of the explicit variables, respectively. The first factor can be referred to as a general factor that includes a combination of energy and human development indicators. The second factor was referred to as investment science.

Table 5. Rotated Component Matrix

Variable	Component		Communalities Extraction
	1	2	
Energy efficiency	0.83	0.35	0.81
Per capita total primary energy supply	0.92	0.35	0.96
Per capita carbon dioxide emissions	0.91	-0.35	0.85
Total greenhouse gas emissions except for land use change and forestry	0.95	0.18	0.95
Scientific citations	0.52	0.76	0.87
Number of scientific papers	0.34	0.78	0.73
Research and development costs (percentage of GDP)	-0.79	0.15	0.66
KOF Globalization Index	0.74	0.62	0.94
Human Development Index (HDI)	0.78	0.60	0.98
Life expectancy index	0.72	0.65	0.96
Military expenditures (percentage of GDP)	0.04	0.92	0.86
Health expenditures (percentage of GDP)	-0.43	0.84	0.89
Government expenditures on education (percentage of total government expenditures)	0.67	0.21	0.5

Source: Authors' Calculations

Figure 6. Rotated Factors



Source: Authors' Compilation from SPSS

Explanation of the variables in Figure 6 above: X1: energy efficiency, X2: total primary energy supply, X3: scientific citations, X4: scientific papers, X5: KOF, X6: greenhouse gas emissions, X7: human development, X8: army costs, X9: life expectancy, X10: health care costs, X11: education costs, X12: research and development costs, X13: carbon dioxide emissions.

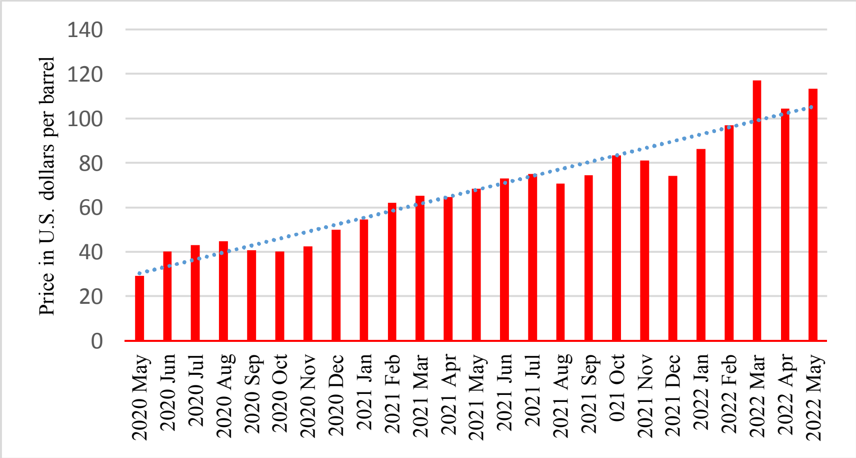
4. 4. Ukraine War and Energy Security Implications

It seems that there is a direct relationship between energy security and stability. With this in mind, in this section, some of the aspects of the Russian invasion of Ukraine and their impact on energy security at the national and international levels will be discussed.

4.4.1. Global Aspect

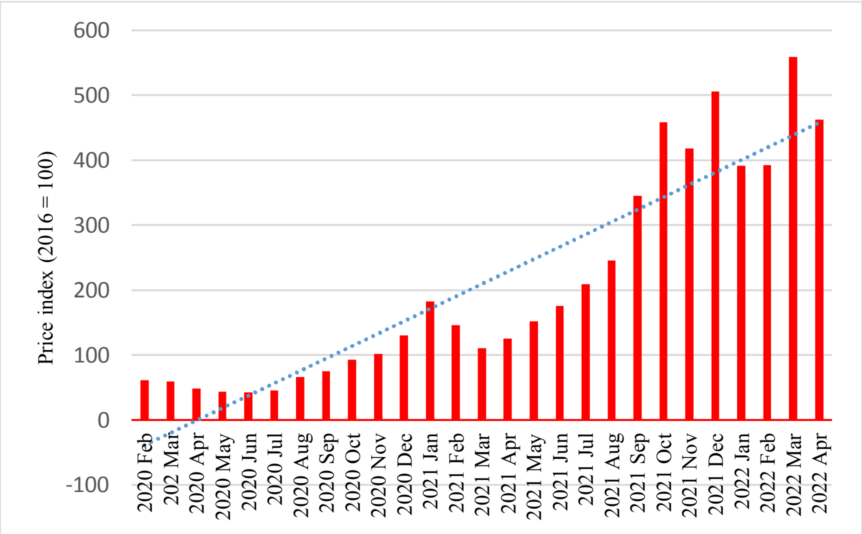
In the energy sector, Russia is one of the world's largest oil producers and exporters and a giant in natural gas markets (International Energy Agency, 2022, Jun. 11). Currently, more than half of the energy consumed in the European Union is imported from Russia. Europe is particularly dependent on Russian energy: 47% of its natural gas, 25% of its oil, and about 30% of its coal are imported from Russia (World Bank ECA Economic Update, 2022; Pach-Gurgul & Piwowarski, 2022). Supply shortages and rising energy and food prices will fuel inflation and affect countries in the region as well as the rest of the world. In May 2022, the average price of a barrel of Brent crude oil was $113.34 (Figure 7). The high oil prices are due to the Russia-Ukraine war and its impact on fossil fuel supplies. The March 2022 price was the highest monthly average since 2008, and the World Natural Gas Price Index was 463.09 index points in April 2022 (Figure 8). A surge in electricity demand, especially in Europe, caused natural gas prices to spike in the second half of 2021, which was the main cause of the global energy shortage, exacerbated by the war between Russia and Ukraine. As a result, the natural gas price index more than quintupled in March 2022 compared to the 2016 baseline (World Bank ECA Economic Update, 2022; Statista, 2022, Jun. 27; Statista, 2022, May. 16). In terms of trade potential, while Russia and Ukraine account for less than 3% of total global exports, including palladium, titanium, wheat, and corn, war and sanctions have weakened the supply chain and connectivity by disrupting trade routes. This exacerbates existing tensions in global value chains and impacts a wide range of industries, including food, automotive, construction, aircraft markers, smartphones, petrochemicals, and transportation (Liadze, Macchiarelli, Mortimer-Lee, & Juanino, 2022; World Bank ECA Economic Update, 2022). As noted by the WTO (2022, Apr. 12), the most immediate economic impact of the crisis was a sharp increase in commodity prices. The organization now expects merchandise trade volumes to grow by 3.0% in 2022, compared to the previous forecast of 4.7% and 3.4% for 2023. In the CIS region, imports are expected to decline by 12.0% and GDP by 7.9% in 2022, while exports are expected to increase by 4.9% as other countries continue to depend on Russian energy. Liadze et al. (2022) estimated the economic costs of the Russia-Ukraine conflict using a global econometric model. Their study revealed that the conflict in Ukraine could reduce the level of global GDP by 1% by 2023, equivalent to about $1 trillion of global GDP, and increase global inflation by 3% in 2022 and by about 2 percentage points in 2023. Umar, Polat, Choi and Teplova (2022) examined the impact of geopolitical risks from the Russia-Ukraine conflict on Russia, European financial markets, and global commodity markets. Their research suggest that their relationship has changed as a result of the conflict and that European equities and Russian bonds are the net transmitters of shocks. Qureshi, Rizwan, Ahmad, and Ashraf (2022) examined the impact of the conflict on systemic risk in Russia, Ukraine, France, Germany, Italy, the United Kingdom, the United States, and China. The results of the study warn against the accumulation of systemic risk, as sanctions could have a negative impact not only on Russia, but also on European countries and the United States, as well as the rest of the world. As discussed by Balbaa, Eshov, and Ismailova (2022), the Russia-Ukraine war has generally proven that sanctions against a country in conflict are not an optimal solution because they have an undue impact on other countries not involved in the conflict, especially when the countries involved in the conflict are trading partners of other countries not involved in the conflict. Therefore, the measures should be reciprocal to reduce the damage and ensure the stability of energy security in the long term. Misik (2022) believed that the European Union must support its member states' energy security during the transition period, until it will be provided by domestic low-carbon energy sources.

Figure 7. Average monthly Brent crude oil price from May 2020 to May 2022 (in U.S dollars per barrel)



Source: Authors' compilation from Statista, 2022, Jun. 27

Figure 8. Monthly natural gas price index worldwide from Feburary 2020 to April 2022



Source: Authors' compilation from Statista, 2022 May 16

4.4.2. Mutual Measures

In response to the 2009 Russian-Ukrainian gas dispute and its impact on EU countries, the European Commission adopted documents on February 25 to create an Energy Union. The goal of this project was to create energy security, especially for countries that rely on single-source energy supply. However, EU member states were not generally interested in this idea due to different national interests. Some of them had positive economic and political relations with Russia (Pach-Gurgul & Piwowarski, 2022). Regarding Russia's Western response to the recent crisis, members of the International Energy Agency (IEA) committed to release 62.7 million barrels of oil reserves under a post-invasion joint action agreed on March 1, 2022. On April 1, they agreed to release an additional 120 million barrels from emergency stocks. This is the largest stock release in the IEA history, as is the release of additional barrels from U.S. strategic petroleum reserves (International Energy Agency, 2022, Jun. 11). As part of this overall effort, the European Commission is helping member states reduce their dependence on Russian fossil fuels through technical assistance. To this date, seventeen European countries have joined the project. On February 22, Germany expressed disappointment over the approval of a new gas pipeline to be built from Russia and is now considering importing liquefied natural gas from countries such as Qatar and the United States. Belgium is reconsidering its phase-out of nuclear power, while Italy, the Netherlands, and the United Kingdom are pushing to expand wind power. This support is in line with the REPowerEU initiative, in which the Commission described, on May 18, how to end the EU's dependence on Russian fossil fuels and accelerate the transition to clean energy and energy diversification (International Energy Agency, 2022, May. 24; Tollefson, 2022; Astrov, Grieveson, Kochnev, Landesmann, and

Pindyuk 2022). In addition to EU countries, the U.S. withdrew MFN[1] status from Russia and imposed a complete ban on oil imports from Russia and technology exports to Russia. They also imposed a ban on the Russian Central Bank and the bank's foreign assets were frozen. Japan, South Korea, and many European countries have also imposed economic sanctions on Russia to weaken the Russian economy and force the country to roll back the invasion. These sanctions target the most important sectors of any economy and fall into four main categories: Banking and Finance, Energy, Military, and Trade. Regarding trade exchanges between the West and Russia, the European Commission has banned the sale of aircraft, spare parts, and other equipment to Russian airlines. Many international corporations, financial institutions, and media houses have ceased operations in Russia or withdrawn from the Russian market and in a major move, the U.S. government imposed sanctions on Gazprom (Kingsly, cited in Sebastian, 2022; Balbaa et al., 2022; Klisauskaite, 2022, Feb. 25). Dadabaev and Sonoda (2022) presented silence as a strategic approach adopted by Central Asian states in response to the Russia-Ukraine crisis. They showed that strategic silence is an approach that Central Asian states use to express their disapproval of Russia's actions in Ukraine, while avoiding being victimized by Russia and its allies for their open anti-war stance. Russia plays a crucial role in supplying gas from Central Asia to Europe and the countries of the Commonwealth of Independent States (Ministry of Energy of the Russian Federation, 2010, p. 21). As stated by Josep Borrell (2022, Apr. 26), Vice-President of the European Commission, the international community—primarily through the General UN Assembly—has three times expressed its disapproval of the invasion, as it contradicts the basic principles of global coexistence,

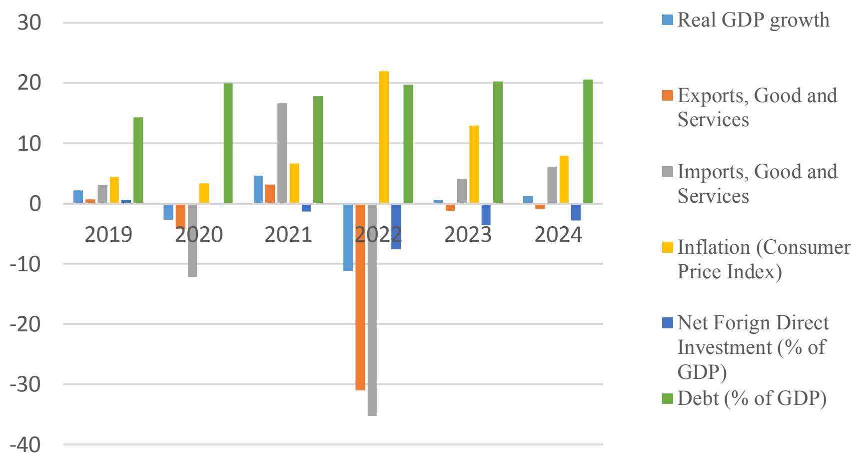
1. Most Favored Nation

as expressed in the Charter of UN: equal sovereignty of states, peaceful settlement of conflicts, and the prohibition of the use of force in international relations.

4.4.3. Effects on Russia and Political Implications

It appears that the impact of sanctions on Russia's energy security will be rather different in the short and long term. As discussed by Hausmann et al. (2022), the decline in the amount of Russian energy entering the market and the expectation of potentially more severe sanctions in the future have increased the price of Russian energy globally, and particularly in Europe, as it is still supplied. On the one hand, a partial decline in volumes from Russia will not diminish Russian energy revenues in the short term, and the increase in prices has already more than offset the loss of volumes due to the embargo on some countries. For example, in the first 100 days after the invasion of Ukraine, Russia earned €93 billion in revenues from fossil fuel exports, despite a drop in export volumes in May. The EU imported 61% of that, worth about €57 billion, according to a detailed record of Russian oil, gas, coal, and pipeline exports by the Center for Energy and Clean Air Research. Revenues have increased due to high global fuel prices, although the volume of Russian exports has declined (Myllyvirta & Krynytskyi, 2022, Jun. 14). On the other hand, tensions between Russia and Ukraine would threaten global energy security, mainly because of energy supply instability and the resulting increase in energy prices. Although the full economic impact of the Russian-Ukrainian war is not yet foreseeable until the end of the conflict, early economic indicators indicate that this war is having a significant impact on the Russian economy. Figure 9 shows the six-year time series of indicators of the macroeconomic outlook through 2024. By 2022, the severe impact of the sanctions already imposed is expected to reduce four indices of Russian GDP by 11.2%, exports of goods and services by 30.9%, imports of goods and services by 35.2%, and net foreign direct investment by 7.5%. Russia's inflation and debt are expected to rise to 22% and 19.8%, respectively. Hoffmann and Neuenkirch (2017) analyzed the impact of the pro-Russian conflict on stock returns in Russia and Ukraine in the period from November 21, 2013, to September 29, 2014; their analysis reveals that the (de)escalation of the pro-Russian conflict in Ukraine is responsible for a fluctuation of approximately 14.6 (33.4) percentage points in the Russian (Ukrainian) stock market. In addition, for the Russian stock market, news from international sources is more relevant for investors than news from Russian sources. As discussed in the World Bank's ECA Economic Update (2022), risks are more tilted to the downside, as further rounds of sanctions could further hurt Russia's prospects. Disruptions in oil and gas revenues or more severe disruptions in domestic financial markets could lead to slower growth and higher poverty rates.

Figure 9. Russian Federation / Macro Outlook Indicators (annual percent change)



Source: Authors' Compilation from World Bank ECA Economic Updates, (2022) Regarding Russia's response to energy sanctions, it is important to consider the main structural constraints in the economic and energy sectors. Russia's most powerful national financial group (Lukoil, Tatneft, Sibur Holding), transnational corporations (Gazprom, Rosneft), and small oil and gas companies (Sibir Energy PLC, West Siberian Resources) operate in the oil and gas complex. The oil and gas complex has traditionally been the agency that ensures the country's energy security (Kuzmina et al., 2020). Vatansever (2020) points to three main obstacles for the Russian oil industry, including the tax system, the industry's organizational structure, and its chronic technological backwardness. In other words, Russia had structural problems in the oil industry even before the sanctions. In 2021, before the Ukraine crisis, new economic conditions were associated with a decline in demand for oil and its products, a heavy reliance on imports, and the cessation of well exploitation for the signing of an agreement under OPEC ++, resulting in a market decline of 3-10%. As a result of the pandemic and self-isolation by 2020, the Russian oil and gas industry has lost 50-60% of its revenues from the export of hydrocarbons, and more than 50% of its capitalization. Today, Russia's national financial group, transnational corporations, and small oil and gas companies operate in conditions of negative deterioration, the domestic market is shrinking, crack propagation is reduced, and production growth is limited (Kuzmina, Parhomchuk, and Minakova, 2020).

Overall, the impact of the Russian-Ukrainian war on energy security policy making could be considered in a variety of areas, including national, regional, and global. Russia's invasion of Ukraine has the potential to accelerate the global green energy transition in the long term. Countries are working on contingency plans in case of oil and gas shortages. Renewable energy investments are seen as part of energy security and political stability. In the longer term, therefore, policymakers can accelerate the transition to low-carbon energy sources at home by encouraging investment in renewable energy. In addition, the IEA's 10-Point Plan to Reduce Oil Consumption proposed 10 actions that can be taken with immediate effect to reduce oil demand. Immediate action in advanced economies could reduce oil demand by 2.7 million barrels per day over the next four months (Katser-Buchkovska 2022, Apr. 29; Guénette, Kenworthy, & Wheeler, 2022; International Energy Agency, 2022 Mar. 3; International Energy Agency, 2022, Mar. 18). Russia could build a substantial business focused on Asian markets, but the transition will be neither immediate nor easy and will depend critically on foreign partners, including China. In February 2022, Gazprom signed an agreement with China National Petroleum Corporation to supply an additional 10 bcm to China via the Far East. However, Ediger, Bowlus, and Dursun (2021) explain that Russia's future ability to monetize its hydrocarbons will depend on China, which ultimately prefers to avoid importing these hydrocarbons for economic, environmental, and diplomatic reasons, as it seeks industrial and technological leadership to produce clean energy. Moreover, Russia's ability to further increase gas sales to Asia depends on new LNG projects, such as Arctic 2, Ust-Luga, or Baltic LNG and Arctic 1. In this line, it should be noted that these projects rely on foreign partners, both as capital partners and financiers, and as providers of key technologies and project management expertise (Tsafos, 2022, May. 4). The development of energy cooperation with the countries of the CIS, the Eurasian Economic Union, Northeast Asia, and the Shanghai Cooperation Organization is considered Russia's main energy strategy for the period up to 2030 (Ministry of Energy of the Russian Federation, 2010, p. 58). As stated in the works of Kuzmina et al. (2020), Cherepovitsyn, Rutenko, and Solovyova (2021), Carayannis, Ilinova, and Cherepovitsyn (2021), Cherepovitsyn and Evseeva, (2021), and Matkovskaya, Vechkinzova, and Petrenko (2021), oil and gas companies need to look for new opportunities, urgently identify the reasons for non-innovative development of oil and gas companies, and use innovative technologies to maintain the profitability of oil and gas production, sustainable development of oil and gas fields in the Arctic, and development of small and hard-to-develop deposits. Therefore, Russia needs to localize energy science and technology, which, given the shadow of Western sanctions and dependence on the transfer of energy technologies from the West to Russia, will significantly contribute to increasing the country's energy security in the long term.

5. Conclusion

In general, the share of primary energy consumption in its various forms has not changed significantly in Russia over the past two decades. Yet, natural gas, oil, and coal have each prescribed a total of 87% of energy consumption in 2020 among the eight sources. The challenge for Russia in the coming years is to develop a new strategy for the development of its energy sector, which will enter volatile territory due to increasing global competition, technological foreclosure, and financial constraints if it fails to influence the climate change agenda. Russia ranks fourth in the world in terms of primary energy consumption and carbon dioxide emissions. At the same time, de-carbonization of the energy sector is not in sight. Energy intensity is high per unit of GDP, and is supported by relatively low energy prices, high capital costs, and massive fossil fuel subsidies.

To measure energy security from a demand-side management perspective and using the energy intensity indicator, two measures were used: total final energy consumption per unit of GDP and total energy supply per unit of GDP. As mentioned earlier, energy intensity is a measure often used to assess energy efficiency in a given economy. Its numerical value is calculated based on the ratio of energy consumption (or energy supply) to GDP, and indicates how well an economy converts energy into money. The energy intensity indicator decides the extent to which there is separation or independence between energy consumption and economic growth. The results indicate that not only has the separation or gap between energy consumption and GDP (economy) not widened in Russia over the past two decades, but that dependence and convergence have persisted. The results of the Pearson correlation test also reveal the significance of the relationship at a 99% level and the high intensity of the dependence between the two variables. Thus, it can be argued that on average over the last two decades, energy intensity has not only not decreased, but has even increased at times, especially after 2010, and that in general, there has been minor improvement in 2018 and 2019; as a result, Russia is far from the desired situation in terms of energy sustainability as one of the important components of energy security.

The results of the exploratory factor analysis indicated that the two obtained factors, as latent variables, are able to explain approximately 85% of the variance of the measured and observed variables. Due to the nature of the variables, these factors were named general factor and investment science factor.

Russia's invasion of Ukraine and its impact on energy security have been studied at various levels. The short-term effects of sanctions must be separated from the long-term effects. In the short term, Russian energy revenues have increased due to high global fuel prices, although the volume of Russian exports has declined. Although the full economic impact of the Russian-Ukrainian war remains to be investigated until the end of the conflict, early economic indicators indicate that this war has had a significant impact on the Russian economy, as structural problems existed in the economic structure, particularly in the hydrocarbon industry, even before the sanctions. In general, Russia's invasion of Ukraine has the potential to accelerate the global transition to green energy in the long term; as a result, investments in renewable energy are seen as part of energy security and political stability. It seems that energy transition will bring more difficulties for Russia and suffers from the problem of energy stickiness due to its economic and political structure, as well as its hydrocarbon culture. Considering the technological and social discontinuity caused by the power structure, as well as the internal and external conflicts triggered by the Ukraine crisis, Russia will lag behind the West in the medium- and long-term renewable energy replacement program.

As a strategic policy, Russia should turn to the following points. The first point is the localization of energy science and technology, which will greatly contribute to increasing energy security in the country in the long-term due to the shadow of Western sanctions and dependence on the transfer of energy technologies from the West to Russia. Secondly, reducing energy intensity (consumption of one unit of energy in the production of one unit of goods) is one of Russia’s strategic policies to increase energy security. To achieve this policy, such programs as changing the production patterns of economic goods, updating production technologies, increasing energy efficiency, and developing environmentally friendly production of goods are useful.

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