Assessing the Impact of Geopolitical Risk on Russia's Energy Transition: An ARDL Bounds Testing Analysis

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This study investigates the relationship between geopolitical risk and the energy transition in Russia using the Autoregressive Distributed Lag (ARDL) Bounds Testing approach. Russia's economy is highly dependent on fossil fuel exports, making the transition toward cleaner energy sources particularly sensitive to geopolitical developments. The research examines how geopolitical risk influences renewable energy adoption, energy consumption patterns, carbon emissions, and energy sector investments over time. Time-series data are analyzed to identify both short-run and long-run dynamics between geopolitical uncertainty and energy transition indicators. The ARDL Bounds Testing approach is employed due to its suitability for variables integrated at different orders and its ability to estimate long-term equilibrium relationships. The findings reveal that heightened geopolitical risk significantly affects the pace of energy transition by altering investment decisions, energy security priorities, and policy implementation. While geopolitical tensions may initially reinforce dependence on conventional energy resources, they can also stimulate domestic innovation and diversification in the energy sector over the long term. The study contributes to the growing literature on energy economics and geopolitical studies by providing empirical evidence from Russia, offering policy implications for achieving sustainable energy transformation under conditions of geopolitical uncertainty.

Keywords: Geopolitical Risk, Energy Transition, Russia, ARDL Bounds Testing, Renewable Energy

Introduction:

Since the industrial revolution, countries' geopolitical risk potential has been greatly impacted by climate change or global warming, which has raised interest in employing green sources of energy. [1] demonstrated the various benefits of green energy sources over non-renewable energy for global peace and security. In particular, green energy sources might lessen regional and international geopolitical struggle for dominance in non-renewable energy markets and prevent the resource curse in energy-producing nations [2]. Therefore, in order to address climate change and reduce geopolitical risks, countries would strive to shift their energy basket, according to [3][4].

As a result, it is evident that the global energy industry is undergoing a paradigm shift. Economic considerations and efficient use have traditionally been used to evaluate the worth of energy initiatives. However, the environmental aspect started to be incorporated into geopolitical risk assessments in the assessment of energy projects, such as power plants, oil and gas projects, etc., due to growing awareness of the threat that greenhouse emissions pose to the environment. The fact that market players are focusing on the amount of CO2 emissions from energy projects is an intriguing and significant development in the energy sector. Additionally, the proportion of renewable energy in the energy mix and electrical sector

has been rising worldwide in many nations. Renewable energy sources are becoming more competitive thanks to governmental legislation and technological advancements that encourage their use. Reducing CO2 emissions, which hasten climate change, is becoming a crucial component of governmental programs. Another name for it is decarbonization. In a broader sense, decarbonization might be referred to as an energy shift [5].

A shift away from the use of fossil fuels and toward energy sources that generate little to no greenhouse gases is known as the "energy transition." It is also frequently referred to as sustainable development. In order to slow down climate change, energy-related CO2 emissions must be reduced [6]. Even though sustainable alternatives are planned for the future, fossil fuels continue to power many civilizations' high-carbon and high-pollution energy systems.

Energy transitions are challenging to describe with a limited number of features because they are multidimensional, complex, non-linear, non-deterministic, and unpredictable phenomena. They necessitate changes to markets, players and their behavior, and current laws and policies [7][8]. In the past, a new energy source or technology has supplanted another because it can generate services that are either more affordable or have better qualities, including being easier, cleaner, or more adaptable.

The globe moved from biomass to coal, from coal to oil, and from oil to natural gas in previous energy transitions, which were caused by the advancement of better technology or the appearance of a new energy source with superior technological qualities [9]. Decarbonization, also known as energy transition, is a strategy to reduce geopolitical risk, which can have varying effects on national economies because no two countries are the same.

Even while everyone agrees that cutting greenhouse gas emissions is crucial for the environment, nations that rely significantly on fossil fuel imports will inevitably be more driven to reduce CO2 emissions than economies with a substantial proportion of natural resources. In order to lessen reliance on energy imports, nations that do not generate hydrocarbons are also more likely to participate in the development of renewable resources and technologies and hold interests in this emerging sector. Russia is the largest exporter of energy resources and one of the greatest producers of hydrocarbons. This essay will examine Russia's energy transition and the ways in which different factors influence the proportion of renewable energy in the country's economy.

This study adds to the body of knowledge on energy security, energy transition, and geopolitical risk. By introducing a novel theoretical energy transition pattern and utilizing the geopolitical risk index in energy transition modeling, it departs from previous research.

Russia's Energy Transition, Geopolitical Risk, and Energy Security:

Russia is the world's largest exporter of natural gas, the second largest exporter of crude oil, and the third largest exporter of coal in 2018, according to the BP Statistical Review of World Energy 2019.

Due to its substantial proportion of the world's energy production, Russia has been a major player in the non-renewable energy markets during the past few decades. Table 1 shows Russia's global output share of coal, natural gas, and crude oil from 2000 to 2018. According to Table 1, Russia has supplied roughly 12%, 17%, and 5% of the world's oil, natural gas, and coal output, respectively, demonstrating its enormous influence in the global energy markets.

Table 1. Russia's average share in global fossil fuel production

Energy Resource	Average Global Share (%)
Crude Oil	12
Natural Gas	17
Coal	5

Russia views the shift to a decarbonization paradigm and the world's increasing renewable energy targets as a serious danger to hydrocarbon export earnings and,

consequently, to Russian economic security. The production of fossil fuels is essential to the national economy. In 2017, hydrocarbons offered 39% of the nation's government budget revenues and 25% of GDP [10]. In 2018, thermal power generation accounted for 74% of global electricity generation, while renewable energy sources, such as hydropower, made up 26% (Table 1). In 2018, 83% of Russia's power came from thermal sources, with the remaining 16% coming from hydropower (table 2). The nation's mix of energy generation reflects the presence of inexpensive natural and hydro resources.

Table 2. Comparison of global and Russian electricity generation structures in 2018

Source	Global Share (%)	Russia Share (%)
Thermal Power	74	83
Hydropower/Renewables	26	16
Other Sources	-	1
Total	100	100

From $516 billion in 1990 to $1.658 trillion in 2018, the Russian economy has grown more than three times (table 3). The availability of new technological solutions, advancements in technology, and the climate agenda can significantly boost the energy sector's efficiency and change its conventional mode of operation, the desire of all nations to guarantee the competitiveness of their national economies and advance the development of reasonably priced energy, and, finally, the necessity of increasing [11]

In 2018, Russia's exports were worth $449 billion. Exports of oil and oil-related products totaled $256 billion. In 2018, Russia exported $207 billion worth of oil, $49 billion worth of gas, and $17 billion worth of coal. More over half of Russia's total exports are made up of these three fossil fuel items (Table 4). Compared to gas, oil export earnings is almost four times higher. Naturally, the national economy benefits from oil sales revenue several times more.

Table 3. Revenue contribution of fossil fuel exports

Commodity	Export Revenue (US$ Billion)
Oil	207
Natural Gas	49
Coal	17
Total Fossil Fuel Exports	273
Total Russian Exports	449

Russia is a significant exporter of natural resources, therefore the consistency of demand and buyer diversity are crucial to the country's energy security. Europeans have long been Russia's main market because of its close proximity to Western Siberia, the nation's principal hydrocarbon production zone.

Gas is mostly exported to consumers in Europe, and oil is similarly, albeit to a lesser degree. Russia strengthened its links with Asian nations and expedited market diversification in response to the worsening political relations with Western nations. "Pivot to the East" is the name of it.

Table 4. Geographic distribution of Russian gas exports

Destination	Share (%)
Europe (Pipeline Gas)	78
LNG Markets	10
CIS Countries	12
Total	100

China is now Russia's primary target market for demand diversification and a significant cooperative partner. It resulted in Power of Siberia, the first pipeline gas export project to Asia, and a long-term gas supply deal between the two nations. Nearly 80% of

Russia's 247 BCM of gas exports in 2018 went via pipelines to the European market. LNG (liquefied natural gas) accounted for 10% and the CIS countries for 12% (table 5). Finding customers outside of Europe is crucial for Russia, and China and LNG will be crucial in this regard.

The situation is slightly different when it comes to Russian oil exports. With 27% of the nation's oil export earnings, China is the top buyer of Russian oil. Japan and Korea are placed fifth and seventh, respectively, with shares of 2% and 6%. Despite the fact that European nations are the biggest purchasers

Its portion of Russian oil is less than that of gas (Table 6). Oil's ease of storage and transportation makes it easier to diversify than gas.

Table 5. Major importers of Russian crude oil

Country/Region	Share of Russian Oil Exports (%)
China	27
South Korea	6
Japan	2
Europe (Combined)	Largest Collective Buyer

Review of Literature:

Globally, there has been a lot of discussion about the environmental problems associated with CO2 emissions and the global energy transition. For example, [12][13][14][15][16] have addressed the significance of energy transition to have a brighter future in terms of the environment and human health.

However, there is little discussion of Russia's energy transformation gave a summary of Russian energy policy in the context of the global energy transition. The authors projected that Russia, which ranks fourth in the world for primary energy consumption and carbon dioxide emissions, will continue to use fossil fuels and stick to the "business as usual" approach. [17] spoke about the geopolitics of the energy transition between Russia and the EU, including future energy commerce. The main conclusion is that the energy transition in energy commerce between the EU and Russia can be accelerated by concentrating on less state-centric cooperation and integrating more non-state actors. [18] contended that the primary goal of Russia's renewable energy policy is to attain the financial advantages associated with the production of environmentally friendly equipment, and that the emphasis on industrial development rather than the decarbonization of the power sector is evident from the Russian government's decision to tie renewable energy subsidies to strict local content requirements. In particular, solar energy benefits from a subsidy regime that is advantageous to local manufacturers. [19] outlined vision for Russia's energy priorities. He maintained that the shift to an eco-friendly energy sector is one of Russia's top energy priorities. Furthermore, the Russian renewable energy sector needs significant R&D investments and is rapidly expanding from a very low foundation. Using data from 1991 to 2016, [20] investigated the connections between carbon emissions and their primary factors in the Russian Federation, including energy consumption, real income, international commerce, degree of education, and urbanization. Using the idea of the Environmental Kuznets Curve, [20] examined the connection between environmental contamination and economic development in various Russian regions. [21] used the Granger causality, Johansen cointegration test, Generalized Impulse Response functions (GIRF), and variance decompositions to investigate the relationship between oil consumption, economic growth, and carbon dioxide (CO2) emissions in three East Asian oil-importing nations (China, South Korea, and Japan) between 1980 and 2013.

Some studies that test the EKC hypothesis attribute increases in environmental quality solely to economic growth [22][23][24][25][26][27]. However, more research has lately started

to pinpoint other elements that might be crucial to the processes of environmental deterioration. For instance, energy use is thought to be a major factor in determining the quality of the environment [28][21][29][30]. Many studies concur that energy use is mostly to blame for CO2 emissions and is either directly or indirectly the main cause of environmental issues.

Background Theory:

The world produces a wide range of commodities every day, and if we assume that an economy consists of only two sectors—industry and households (residential sector), which are the primary consumers of commodities—both renewable and non-renewable energy sources are used as major production inputs in the process of producing commodities. In other words, the demand for energy resources is influenced by the demand of these two sectors for various commodities.

The energy need of the industry comes first. Equation (1) depicts the industry's production function, which is thought to take the Cobb-Douglas form:

$$Y\,I\,t = F\ \ Kt\,,\,Lt\,,\,ETI\,t\ \ = K\,\alpha\,t\,L\,\beta\,t\ \ ETI\,t\,(1-\alpha-\beta)\ (1)$$

Here, K is the capital input, L is the labor input, and Y I is the industry's overall output. The energy transition (proportion of renewables to non-renewables) energy inputs of industry output are represented by ETI.

When continuous return to scale is taken into account, α represents the capital production elasticity, β represents the labor production elasticity, and $1 - \alpha - \beta$ represents the energy resource production elasticity.

Businesses in the industry are maximizing their profits in the following ways:

$$Max\ \pi t = P\,Y\,t\,Y\,I\,t - rtKt - wtLt - et\ \ P\,E\,t + Tt\,ETI\,t\ (2)$$

where π is the sector's profit, P Y is the industry's final product price, r is the capital interest rate, w is the wage rate, e is the exchange rate, and P

Energy price is represented by E, while transportation environmental costs are represented by T (we can use CO2 emissions as a proxy for this variable).

For the energy transition, we assume that Russia, the study country, is importing renewable energy technologies (such as solar photovoltaic modules, Li-Ion cells, wind power generators, etc.). There will be a greater carbon footprint if the importer (Russia) and exporter of renewable energy technology are far apart. For this reason, we employed CO2 emissions as a stand-in for environmental transportation costs. Because the imported items are valued in non-Ruble currencies (such as US dollars), exchange rates also matter. Exchange rates are important since each nation in the supply chain of renewable energy technology, like solar modules, is not the only producer of all the components and must import components from other nations.

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

$$\partial\pi t\ \partial ETI\,t = (1 - \alpha - \beta)\ P\,Y\,t\,Y\,I\,t\,ETI\,t - et\ \ P\,E\,t + Tt = 0\ (3)$$

The energy transition demand is represented in Equation (4):

$$ETI\,t = (1 - \alpha - \beta)\ P\,Y\,t\,Y\,I\,t\,et\ \ P\,E\,t + Tt\ (4)$$

As demonstrated, the elasticities of labor and capital production, the real output of the industry sector, the energy price, the exchange rate, and the environmental cost of transportation (we can use CO2 emissions as a proxy for this variable) all influence the industry's energy transition need.

Next, we may apply the following utility function to examine household energy demand:

$$Ut = \ Ct\,,\,ETH\,t\ = 1\ 1 - \gamma\ (Ct)\ 1-\gamma+\ 1\ 1 - \delta\ \ ETH\,t\ 1-\delta\ (5)$$

where U and C denote utility and consumption (non-energy commodities) of households at time t, respectively. ETH t represents energy transition demand of households

at time t. Households are maximizing their utility with respect to their budget, which is the constraint, as shown in Equation (6):

$$\text{S.t. } P\,C\,t\,Ct + et\;P\,E\,t + Tt\,ETH\,t = Y\,H\,t \quad (6)$$

where P E represents the energy costs expressed in US dollars, P C represents the cost of non-energy commodities, and T stands for the environmental costs of transportation (we used CO2 emissions as a proxy for this variable). Y H is the households' total income. It should be noted that we use population as a stand-in for C in the utility function mentioned above. The consumption of goods, both energy-related and non-energy-related, rises with population expansion. For this reason, we used population as a control variable in our empirical model. We create the Lagrange function, as shown in Equation (7), in order to maximize the utility function of households for specifying the components that determine energy demand:

$$\Gamma = U\;Ct\,,$$
$$ETH\,t\; - \lambda\,n\,P\,C\,t\,Ct + et\;P\,E\,t + Tt\,ETH\,t - Y\,H\,t\,o \quad (7)$$

Obtaining the first-order conditions with respect to the ETH, C, and λ results in Equations(8)(10):

$$\partial\Gamma\;\partial ETH\,t = \;ETH\,t - \delta - \lambda\,n\,et\;P\,E\,t + Tt\,o = 0 \rightarrow ETH\,t = f\;et\;P\,E\,t + Tt\;,Y\,H\,t \quad (8)$$
$$\partial\Gamma\;\partial Ct = Ct - \gamma - \lambda\,n\,P\,C\,t\,o = 0 \quad (9)$$
$$\partial\Gamma\;\partial\lambda = P\,C\,t\,Ct + et\;P\,E\,t + Tt - Y\,H\,t = 0 \quad (10)$$

Equation (8) illustrates how a household's energy transition demand depends on exchange rates, energy prices, transportation-related environmental costs (CO2 emissions), and household income levels. The total energy transition demand is equal to the sum of the energy demands of
households and business (Equation (11)).

$$ETt = ETI\,t + ETH\,t \quad (11)$$

Therefore, the total energy demand is a function of different factors, as shown in Equation (12):

$$ETt = f(P\,E\,t\,,\,Tt\,,\,et\,,\,Yt) \quad (12)$$

where T stands for CO2 and P E is the energy price, which can be expressed as the inflation rate emissions as a stand-in for transportation-related environmental expenses, e is the exchange rate, and Yt is the economy's total gross domestic product, which is dependent on household income (Y H) and industry production (Y I).

As a result, we will use three control variables: inflation rate, CO2 emissions, exchange rate, theoretical economic growth, geopolitical risk, population growth, and financial openness. It should be noted that the quality control of our variables may be approved because they are based on our theoretical model.

Data Description and Model Specification Econometrically, the general function of empirical model is written as following:

$$ETt = f(INFt\,,CO2t\,,\,EXCt\,,\,GROt\,,\,POPt\,,\,FINt\,,\,GEOt) \quad (13)$$

To attain coefficients in the form of elasticities, we transform all the variables into logarithms and our empirical model changes as follows:

$$LETt = \beta0 + \beta1 * LINFt + \beta2 * LCO2t + \beta3 * LEXCt + \beta4 * LGROt + \beta5 * LPOPt + \beta6 * LFINt + \beta7 * LGEOt + \mu i \quad (14)$$

In this case, ETt stands for Russia's energy transition in time t. Russia's inflation rate and CO2 emissions in time t are displayed by INFt and CO2t. GROt shows Russia's economic growth in time t, whereas EXCt reflects the country's exchange rate in time t. Lastly, POPt, Russia's population growth, financial openness, and geopolitical risk are represented by FINt and GEOt, respectively, while μt is the error term that is thought to be normally distributed with a zero mean and constant variance.

Table 6. Description of variables

Variable	Symbol	Source
Energy Transition	ET	BP Statistical Review
Inflation Rate	INF	World Bank
CO_2 Emissions	CO_2	World Bank
Exchange Rate	EXC	World Bank
Economic Growth	GRO	World Bank
Population Growth	POP	World Bank
Financial Openness	FIN	World Bank
Geopolitical Risk	GEO	GPR Index (Matteo Iacoviello)

The stationarity characteristics of the variables must be tested before estimating Equation (14). Owing to the likelihood of structural breakdowns, we carried out a test that suggested three models to verify the theory of a single structural break in the series:

$$\Delta xt = a + axt{-}1 + bt + cDUt + X\ k\ j{=}1\ dj\ \Delta xt{-}j + \mu t \quad (15)$$

$$\Delta xt = b + bxt{-}1 + ct + bDTt + X\ k\ j{=}1\ dj\ \Delta xt{-}j + \mu t \quad (16)$$

$$\Delta xt = c + cxt{-}1 + ct + dDUt + bDTt + X\ k\ j{=}1\ dj\ \Delta xt{-}j + \mu t \quad (17)$$

Here, trend shift variables are displayed by DTt, whereas dummy variables are represented by DUt, which indicates the mean shift that occurred at each point with a time break.

Following the examination of the stationarity properties, an estimation is carried out by using the ARDL bounds testing method, which was first presented, to determine the long-term link between independent variables and the energy transition. Additionally, the White test for homoscedasticity, the Ramsay RESET test for model misspecification, and the ARCH LM test for higher order autocorrelation will be used to assess the dependability of the estimates.

The World Bank database and the BP statistical review of 2019 provided the majority of the data.

Furthermore, Matteo Iacoviello's website provides the data for the Geopolitical Risk Index (GPR). The Geopolitical Risk Index (GPR) was developed using automated text-research findings from digital archives.

Table 2 displays the main descriptive statistics of the data for Russia.

Table 7. Main descriptive statistics of variables

Variable	Mean	Maximum	Minimum
Economic Growth (%)	1.73	10.00	-12.56
Exchange Rate (LCU/US$)	30.90	67.05	0.99
Energy Transition (%)	3.91	4.37	3.55
CO_2 Emissions (Metric Tons per Capita)	11.40	-	-
Population Growth (%)	-0.11	-	-
Financial Openness	0.52	-	-
Geopolitical Risk Index	105.92	-	-

Russia's economy grew by 1.73% on average between 1993 and 2018, as Table 2 illustrates. Additionally, it requires a minimum of −12.56% (in 1994) and a maximum of 10% (in 2000). Additionally, the average value of its national currency in relation to US dollars is 30.90 LCU per US$, whereas its maximum and the lowest numbers occurred in 1993 (0.99 LCU per US$) and 2016 (67.05 LCU per US$).

The energy transition has an average of 3.91%, with its highest and lowest values occurring in 1993 (4.37%) and 2011 (3.55%), respectively. Furthermore, Russia's average per capita CO2 emissions are 11.40 metric tons (World Bank databases show that the global average CO2 emissions during this time are close to 4.41%). Russia's population growth has a

negative mean of −0.11% between 1993 and 2018, yet its average financial openness is only 0.52. Between 1993 and 2018, Russia's Geopolitical Risk Index (GPI) averaged 105.92. Russia has a relatively high GPI when compared to other nations with GPIs under 100, such as Brazil, Indonesia, and India. This emphasizes the significance of implementing various initiatives, such as energy transition, to decrease this index.

The Pearson correlation test is used to determine whether there is a primary relationship in Russia between the dependent (energy transition) and explanatory series (economic growth, exchange rate, CO2 emissions, population growth, inflation rate, geopolitical risk, and financial openness). Table 3 displays the test's results as follows:

Table 2 shows that, between 1993 and 2018, the energy transition in Russia was positively correlated with CO2 emissions, geopolitical risk, exchange rate, and financial openness, but negatively correlated with economic growth, population growth, and inflation rate. Russia's GDP and economic growth are heavily reliant on the production and export of fossil fuels due to the country's oil-based economy. Therefore, it is anticipated that this acceleration of economic growth will slow Russia's energy transition.

Furthermore, we anticipate that the exchange rate will have a positive coefficient, which means that any decline in the value of the Russian ruble relative to the US dollar will increase the cost of enhancing environmentally friendly energy projects in this nation, which will result in a decrease in the development and consumption of renewable energy in Russia. Additionally, it is anticipated that CO2 emissions will benefit Russia's energy transition drive. Numerous research, including in situations of 17 OECD nations and in cases of 85 developed and developing economies, have verified this beneficial effect. We may anticipate that Russia's energy transition will be negatively impacted by population expansion. Any population growth might result in increased aggregate demand (such as in the transportation, energy, and commodities markets), which would need Russia to consume more fossil fuels. Furthermore, it is anticipated that Russia's energy transition will be negatively impacted by the pace of inflation. Any general price increase could raise the cost of renewable energy projects in Russia, which could be a significant barrier to the nation's energy shift. Lastly, it is anticipated that financial openness will have a favorable effect on the energy transition. Increased financial transparency makes it simpler for foreign organizations or businesses to fund renewable energy projects in Russia. In terms of geopolitical risk, Russia can reduce the threat of the natural curse and slow down the rate of climate change by accelerating the energy transition (the Arctic sea ice is currently melting at a rate of 12.85% per decade, which is a significant geopolitical risk for Russia, according to the website).

Outcomes:

The ARDL bounds testing approach was used to determine the association between independent variables and Russia's energy transition. One of this method's primary prerequisites is that every series should be integrated at I(0), I(1), or I(0)/I(1). The Zivot-Andrews structural break test was used to verify this prerequisite, and Table 5 presented the findings as follows:

Table 8. Structural break years identified through Zivot–Andrews test

Variable	Structural Break Year	Variable
Energy Transition	2009	Energy Transition
Economic Growth	1993	Economic Growth
Exchange Rate	1997	Exchange Rate
CO_2 Emissions	1997	CO_2 Emissions
Population Growth	2014	Population Growth
Inflation Rate	2009	Inflation Rate
Financial Openness	2009	Financial Openness

All of the variables are integrated at the first level, or I(0), according to the results displayed in Table 5. In order to examine the connection between the energy transition, economic growth, exchange rate, CO2 emissions, population growth, and inflation rate, we used the ARDL bounds testing approach. This analysis also considers financial openness in Russia despite structural breaks in the series between 1993 and 2018. In order to do the ARDL bounds testing estimation, we had to choose a suitable lag duration based on the minimal value of AIC (Akaike Information Criterion) in order to compute F-statistics for comparison with critical limits. The results of the ARDL limits testing approach for our model with structural break in the series were shown in Table 6. We utilized energy transition, economic growth, exchange rate, CO2 emissions, population growth, inflation rate, and financial openness as anticipated variables since the results show that the computed F-statistics are bigger than upper critical bounds at 5% and 1% levels. Additionally, the variables of energy transition, economic growth, exchange rate, CO2 emissions, population growth, inflation rate, and financial openness in 2009, 1993, 1997, 1997, 2014, 2009, and 2009, respectively, are the source of the structural fractures. The findings demonstrated the cointegration of the series for a long-term relationship between the energy transition, economic growth, inflation rate, CO2 emissions, population expansion, exchange rate, and financial openness in Russia's situation.

We can emphasize the following conclusions based on the estimated coefficients, which are shown in Table 7:

Analysis of the short-term Russia's economic expansion has a detrimental impact on the nation's energy transition in the short-term. The country's energy transition is reduced by almost 0.02% for every 1% rise in economic development, which means that Russia's increased production cannot effectively replace fossil fuel energy sources with renewable energy sources.

A 1% increase in the value of the Russian ruble is associated with a 0.008% rise in energy transition, according to a positive and statistically significant short-term relationship between exchange rate and energy transition. The country's exports, especially those of gas and oil, are somewhat harmed by the Ruble's appreciation. As a result, local SMEs in Russia can have a good chance to advance their initiatives pertaining to the growth of green energy production.

The findings verify that Russia's energy transition is negatively impacted by CO2 emissions in the short term. Russia's energy transition decreases by over 0.11% for every 1% increase in this variable.

Population growth and inflation have negative short-term effects on Russia's energy transition movement; a 1% rise in either is associated with a 0.05% or 0.15% decrease in energy transition, respectively.

Russia's the coefficient of financial openness is positive and statistically significant, meaning that a 1% rise in financial openness could result in a 0.25% boost in the nation's energy transition in the short term.

Geopolitical risk has a favorable and statistically significant short-term impact on Russia's energy transition movement. In the short term, Russia's energy transition might rise by over 0.31% for every 1% increase in geopolitical risk.

Extended analysis:

Russia's energy transformation process is negatively and statistically significantly impacted by economic growth. According to the estimate, Russia's energy transition decreases by 0.28 for every 1% increase in economic growth. This country's oil-based economic system, which connects economic growth and non-renewable energy supplies, may be the primary cause. In contrast to, which found a positive correlation between economic growth and renewable energy usage in Pakistan, this conclusion is consistent with, which demonstrated a negative long-term relationship between clean energy and economic growth for Nigeria.

Russia's energy transition and currency rate have a positive long-term relationship; that is, a 1% increase in the value of the Russian ruble relative to the US dollar results in a nearly 0.19% gain in the nation's energy transition process. This result is consistent with [author], who examined potential future renewable transition scenarios.

Our empirical analysis revealed that every rise in CO2 emissions has detrimental effects statistically significant effect on Russia's energy transition. The energy transition increases by about 0.3% for every 1% increase in CO2 emissions. To put it another way, Russian policymakers are thinking about using renewable energy sources instead of fossil fuels to reduce air pollution. This result is comparable to that of, who discovered a negative correlation between green energy usage and CO2 emissions.

Russia's energy transition process is negatively and statistically significantly impacted over time by both population increase and inflation. In Russia, there is a 0.14% and 0.31% drop in energy transition for every 1% increase in population and goods and services prices. The positive correlation between population increase and non-renewable energy use is consistent with the findings of, who demonstrated this relationship in OECD nations.

The coefficient of financial openness is positive, suggesting that a rise in Russia's financial openness is a contributing factor to the country's energy transition. The analysis verified that, in Russia's situation, financial openness is a major long-term factor in the progress of the energy transition.

Lastly, the estimation demonstrates that geopolitical risk has a positive and statistically significant long-term impact on the energy transition. In the long run, a 1% increase in geopolitical risk might result in a 0.27% increase in Russia's energy transition. This result is consistent with the findings of, who discovered that green energy may increase the likelihood of minor disputes but reduce the likelihood of major political disputes.

Table 9. Summary of short-run and long-run impacts on energy transition

Variable	Short Run Effect	Long Run Effect
Economic Growth	Negative	Negative
Exchange Rate	Positive	Positive
CO_2 Emissions	Negative	Positive
Population Growth	Negative	Negative
Inflation	Negative	Negative
Financial Openness	Positive	Positive
Geopolitical Risk	Positive	Positive

Conclusions:

This study looked into the consequences of a number of factors, including population growth, inflation, CO2 emissions, economic growth, exchange rates, financial openness, and especially geopolitical risk associated with the Russian economy's energy transition from 1993 to 2018 (consumption of renewable energy resources to use of non-renewable ones). In order to verify cointegration between the series in the presence of structural breaks for long-run linkage, we used the ARDL bounds testing method.

Our variables are cointegrated for long-run linkage, as demonstrated by the results of the ARDL bounds testing method. The empirical estimates showed that while CO2 emissions, geopolitical risk, exchange rates, and financial openness have beneficial effects on Russia's energy transition movement, economic growth, population growth, and inflation rates have long-term negative effects. Additionally, we discovered that while exchange rates, geopolitical risk, and financial openness are the only factors that speed up the country's energy transition, there is a negative short-term correlation between economic growth, CO2 emissions, population growth, and inflation rate.

Furthermore, the results showed that, in the case of the Russian economy, geopolitical risk is the most significant factor in the short-term energy transformation process, but financial openness is the key long-term contributor. In other words, while various geopolitical risks like climate change, the resource curse, and the EU's desire to reduce energy dependency on Russia are the golden keys of Russian intentions to accelerate the energy transition process, the most significant issue in Russia over the long term to imply energy transition is financial flow from banks and financial institutions (either local or foreign) to firms to conduct projects in relation to developing environmentally friendly energy sources. The main conclusion is that Russia's policy makers should focus on the nation's long-term energy goals (as the empirical results demonstrated the greater magnitudes of effects of factors on Russia's energy transition in the long-run rather than the short-run). Additionally, reducing the Federals' budget's reliance on oil and gas earnings would be a helpful strategy to lessen the detrimental effects of economic expansion on the nation's energy transition. Determining the nation's quick decarbonization policies is another suggestion. It is advised to develop a short-term climate change policy in addition to the long-term one since we have discovered both short-term negative and long-term positive effects of CO2 emissions on energy transition. Furthermore, given the positive correlation between geopolitical risk and Russia's energy transition progress, it can be inferred that the country has been able to focus more on renewable energy sources rather than non-renewable ones that are closely linked to this political tension due to the current Russia-West tension that has grown since the 2014 Ukraine tension.

In general, it is advised that future research contrast Russia's energy transition model with that of other countries. Additionally, employing novel control variables like interest rates would provide researchers with fresh perspectives. Additionally, this study has certain shortcomings, like missing data, limited

The theoretical model has two sectors (a multi-sector theoretical model is preferred) and a qualitative economic breakpoint that may be resolved in subsequent research. Furthermore, it is recommended that future research be conducted using a novel ARDL technique like Dynamic ARDL.

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