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Towards Achieving Sustainability in the BRICS Economies: The Role of Renewable Energy Consumption and Economic Risk

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Abstract: In this study, the focus is on examining the influence of renewable energy consumption, economic risk, and financial risk on the load capacity factor (LF) within the BRICS countries. The analysis covers the time span from 1990 to 2019. The empirical strategy uses the Method of Moments Quantile Regression (MMQR) and long-run estimators (Fixed Effects Ordinary Least Squares, FE-OLS; Dynamic Ordinary Least Squares, DOLS; and Fully Modified Ordinary Least Squares, FMOLS). The findings highlight the presence of a cointegrating relationship. Moreover, fossil fuels and economic growth cause LF to decrease, while economic risk and the use of renewable energy sources increase the deepening of the LF. Furthermore, the results of the MMQR method are confirmed by DOLS, FMOLS, and FE-OLS estimates. Causality results also demonstrate that these factors may forecast ecological quality, indicating that policies for renewable energy consumption, financial risk, renewable energy, and economic growth can all have an impact on the degree of LF. In light of this research, policymakers should strongly encourage expenditures on environmentally friendly technologies and economic and financial stability to increase energy efficiency as well as sustain the widespread adoption and use of energy-saving products.

Keywords: load capacity factor; sustainable development; financial risk; economic risk; renewable energy consumption; fossil fuels; BRICS; panel data

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1. Introduction

At the beginning of the 19th century, it was clear that the industrialization process had brought about a rapid paradigm change that had caused the world economies to begin a fresh phase of economic growth [1,2]. While manufacturing processes grew more mechanized due to the industrial revolution, mankind moved towards a more utopian form of economic progress. Several countries have relied heavily on Fossil Fuels (FF) combustion like coal, gas, and oil, which produce enormous amounts of Greenhouse Gases (GHGs) and cause a significant climatic shift, to satisfy the demands of production and spur sustainable economic growth [3–5]. Despite the fact that it is clear that the use of FF considerably boosts economic growth, it degrades the ecosystem and causes global warming by producing harmful gases like CO_2. As a result, the Intergovernmental Panel on Climate Change (IPCC) acknowledged in its fifth evaluation report that CO_2 is a key driver of accelerating climate change. Thus, to keep the global temperature below 1.5 °C, environmentalists at the 2015 Paris Meeting suggested substantial efforts toward comprehensive decarbonization [6,7].

The prolonged use of FF-based energy increased climatic variability and the necessity of combating global warming. Research has also documented the upward price fluctuations of FF, which stress the energy sector. Scientists proposed efficient growing energy production and switching to renewable energy as the solutions to cope with the rising global temperature and maintain economic expansion [8–10]. Ref. [11] suggested that sustainable and green energy might assist dramatically in setting the countries on an ecological sustainability route and planning the ensuing strategies for the planet, considering the crucial relevance of energy efficiency and renewable energy [12–14]. To contrast the negative effects of climate change and promote green growth, some countries have tried to identify alternative energy sources [15,16].

A major subject amongst economists due to the depletion of fossil resources and growing global energy consumption is the future energy need [17]. Given that these sources represent the answer to the problems of energy shortage and environmental harm, renewable energy can meet the gap in future energy demand [18,19]. In contrast to the FF, renewable energy sources produce no carbon emissions. Because of its importance in addressing global warming, its low cost compared to FF, and its environmental friendliness, renewable energies may promote green development globally by tackling the problem of energy scarcity [20,21].

Moreover, understanding the impact of economic and financial risk on ecological quality is vital. The discussion of ecological destruction must consider economic and financial risk (FR). This enables mitigation strategies for climate change. Several processes support the interrelationship between economic growth, FR, and ecological quality [22,23]. An increase in investments and productivity due to improved financial and economic stability might result in increased resource usage and, as a result, environmental degradation. Contrarily, a sound economic system may allocate more funds to environmentally friendly initiatives and Research and Development (R&D) expenditures, which in turn may slow down the ecosystem's destruction [24]. High financial risks can also lead to economic instability, which might severely impact environmental policies [25,26]. In addition, it may be relevant to enhance the output during severe financial and economic instability than to protect the environment [27,28]. Thus, the interrelationship between financial and economic risk (ER), which may affect ecological quality, has not been examined in the literature.

The BRICS economies (Brazil, Russia, India, China, and South Africa) constitute a substantial demographic, geographic, and economic bloc on a global scale, contributing to around one-fifth of the world economy [29]. Over the past few decades, these countries have made remarkable strides in economic advancement. In 2016, the combined economic output of the BRICS group reached nearly 22% of the global Gross Domestic Product (GDP), marking a significant increase from 11% in 2005 [30]. In fact, the aggregate GDP of these nations currently surpasses that of the G-7 countries. Consequently, due to their rapid modernization and large populations, the energy consumption of BRICS economies is bound to grow. Collectively, these countries account for approximately 40% of global energy consumption and bear substantial responsibility for CO_2 emissions [31,32]. As evident from their significant global contribution to CO_2 emissions, BRICS nations were responsible for 41% of global CO_2 emissions prior to 2017 [33,34]. Furthermore, these countries possess abundant natural resources. For instance, Russia alone holds 20% of the world's resources and 97.7% of its domestic wealth [35]. Moreover, natural resource operations constitute a significant portion of their economic activities, contributing between 3% and 15% of GDP and serving as a crucial source of export revenues for the Chinese economy [36]. On the other hand, the share of BRICS economies in world trade has witnessed substantial growth, rising from 3.6% in 1990 to 15% in 2010. At present, the total value of commerce, including imports and exports, amounts to USD $5.9 trillion [37].

The current research provides several contributions. Though several studies have evaluated the drivers of ecological quality/deterioration [38–41], to the best of our knowledge, previous studies have only assessed a specific indication of country risks on ecological quality by using a single indicator that is not able to accurately describe the framework. Nevertheless, this study closes the gap by offering a more thorough analysis of how country risks affect ecological quality by considering economic and financial risks. Second, despite the literature highlighting the significance of income and energy use in interpreting the conflicting results of country risks on ecological quality and extrapolating a potential effect, they mostly focused on political risk. This research evaluates how FF, economic growth, renewable energy, and country risks impact ecological quality for a more effective assessment. Third, this research employs the load capacity factor (LF), a broader ecological quality measure. LF considers both the demand and supply sides of the ecosystem, thus representing a precise metric for measuring ecological quality. Fourth, the study closes a gap in earlier research by using the Method of Moments Quantile Regression (MMQR) with fixed effects shown by [42] for the BRICS case. MMQR method is considered suitable because it accounts for the diverse conditional impacts of the regressors that influence the entire distribution rather than each determinant being a mean shifter [43], which is not suitable given that economic growth stages across BRICS economies vary and that their levels of emissions also varied across the nations. Traditional panel long-run estimators—including Dynamic Ordinary Least Squares (DOLS) and Fully Modified Ordinary Least Squares (FMOLS)—account for the problems of endogeneity and cross-sectional dependence, but they still are unable to fully illustrate the distributional influence of the independent variables. The marginal impacts of the regressors at various levels of the conditional distribution of the dependent variable are not picked up by these long-run panel estimators, which only identify the middle values of the regression coefficients. Therefore, despite the conditional distribution of the result variables, mean regression is unable to identify the link between the regressors and the dependent variable [44]. By integrating fixed effects that compensate for the distributional variability at various quantile distributions of the dependent variable, the MMQR technique, in contrast, solves this issue [45]. In addition, MMQR can provide estimates for the non-linear and asymmetric connection between the indicators by concurrently considering heterogeneity and endogeneity issues. Additionally, compared to conventional QR, MMQR estimates are more resistant to outliers and can offer estimates when cross-sectionally linked and endogenous indicators are present [42].

The structure of the paper is the following. The next Section 2 discloses the synopsis of related literature. Section 3 unveils the data and methods used. Section 4 presents the results, while Section 5 gives conclusions with policy recommendations.

2. Literature Review

The planet consumes more resources than it can support, and based on this consumption rate, two more planets will be required by 2050. Thus, the current linear paradigm of resource extraction is unsustainable [25,46–50]. This results from the pro-growth policies of both developed and developing economies. The emergence of the adverse effect of climate change and global warming has pushed several nations to re-strategize their economic growth policies [27]. As a result, several nations are shifting their policies toward sustainable growth. This shift can be achieved by using sustainable energy, which researchers, policymakers, and intergovernmental organizations have highlighted [51,52]. Thus, boosting the green/renewable energy percentage in their energy portfolio is suggested. Sustainable energy use can also be promoted through eco-friendly technologies.

The empirical literature has documented studies focusing on the role of country risk, economic growth, sustainable energy, and FF. However, no conclusive policies have been drafted so far regarding the nexus between ecological quality/deterioration and economic indicators. These inconclusive findings have been attributed to the difference in techniques used, time span, and economic structure of the nations. For example, Ref. [1], drafting policies to reduce GHG emissions, used the MMQR method to evaluate the drivers of GHG emissions by incorporating economic policy uncertainty, real growth, green energy, and FR between 1990 and 2019. The results revealed that the decrease in GHG emissions in Mexico, Indonesia, Nigeria, and Turkey (MINT) economies is caused by an upsurge in FR and green energy, while real growth and economic policy uncertainty intensify GHG emissions.

Ref. [53], using a dataset on five Scandinavian countries over the 1990–2018 time period, found that renewable energy consumption (REC) is a useful policy instrument to reduce CO_2 emissions without adversely affecting GDP growth. Similarly, Ref. [9], using data on the Brazilian economy, tested the contribution of renewables to this economy with a Machine Learning (ML) architecture through a Long Short-Term Memory (LSTM) model. Empirical findings show that an ever-greater use of renewables may sustain the economic growth recovery, generating a better-performing GDP acceleration vs. other energy variables.

Ref. [54] performed Augmented Mean Group (AMG) and Common Correlated Effects Mean Group (CCEMG) estimators to evaluate the drivers of CO_2 emissions by incorporating globalization, real growth, and green energy between 1990 and 2019. The results show that a decrease in CO_2 emissions in BRICS economies is caused by an upsurge in green energy and globalization, while real growth and dirty energy spur CO_2 emissions. Moreover, Ref. [55] analyzed the drivers of CO_2 used data from 1990 to 2018 and considered the role of renewable energy through the Fourier-based approach, providing that eco-innovation along with green energy decrease CO_2 emissions.

Ref. [56] used the Auto-Regressive Distributed Lags (ARDL) method and time-varying causality tests to evaluate the role of energy and innovation along with green energy on CO_2 emissions. The case of South Africa was investigated using data from 1990 to 2019, and the results highlighted that the decrease in CO_2 emissions is caused by green energy and globalization, while real growth and dirty energy intensify CO_2 emissions. Moreover, Ref. [57] investigating the drivers of CO_2 emissions using the Fourier-based approach documented that eco-innovation, as well as green energy, promote the decrease of CO_2 emissions.

Gap in the Literature

While investigations on the carbon-income-energy interrelationships are quite abundant, there is a paucity of documentation on load capacity-income-energy analysis by considering the role of country risks. Ref. [49] explored the impact of aggregate income and energy consumption on environmental quality in the case of Thailand. Moreover, Ref. [58] for Brazil considered the link between REC and economic growth. Therefore, the relevant influence of ER and FR on environmental sustainability is scant in the related literature, particularly for BRICS nations. To that purpose, the present research contributes to the existing knowledge in several aspects. First, this study considers the role of ER and FR in the relationship between ecological quality (proxied by LF) and renewable energy consumption for BRICS nations. Second, in terms of scope (BRICS nations), this research adds to the existing literature a new case study. Lastly, this work employs recent econometrics methods, including Westerlund's panel cointegration test in combination with FE-OLS, FMOLS, DOLS, MMQR estimator, and panel causality tests, which are selected to overcome the drawbacks of first-generation methodologies. All estimators are more resilient to cross-sectional dependence and heterogeneity concerns than the first-generation estimators. As a result, for effective policy formulation, the present research relies on second-generation tools for sturdiness and coherence of estimates and coefficients.

3. Theoretical Framework, Data, and Methods

3.1. Theoretical Framework and Model

This section presents information regarding the theoretical linkage among the studied variables. At the early phase of economic development, most developing countries support economic expansion while little or no attention is paid to ecological sustainability [59]. This phase is also recognized as a scale effect. This scenario includes emerging nations such as the BRICS economies [6]. However, when a certain threshold is attained, income growth is expected to lead to the demand for ecological quality [60]. Consequently, an increase in income will trigger ecological quality [44]. This phase is also known as the composite and technique effects. Thus, in this study, economic growth and its squared term are expected to decrease and increase ecological quality, respectively: $\beta_1 = LF/GDP < 0$ and $\beta_2 = LF/GDPSQ > 0$. Because energy is the lifeblood of every economy, an increase in energy consumption leads to an increase in economic production [24]. Furthermore, energy consumption has an impact on a country's ecology. As a result, a rise in energy consumption, which is often satisfied by the burning of FF, generates GHG emissions, consequently degrading the ecosystem [61].

An alternative to FF sources is required to reduce the environmental effect of energy use. Renewable energy solutions are frequently environmentally favorable [62]. The discovery and application of these energy sources may assist in reducing dependency on FF while simultaneously improving ecological quality. Therefore, we expect nonrenewable and renewable energy to decrease and increase ecological quality, respectively: β_3 = LF/FF < 0 and β_4 = LF/REC > 0.

The role of country risk (i.e., economic, financial, and political risk) on ecological sustainability has recently become a hot topic in energy and environmental literature. According to [63], a stable political system aids in formulating policies that would influence the ecosystem positively. This notion is also supported by [64] conclusions. In addition, the economic stability in a country attracts foreign investments, boosting economic growth. However, the growth of these investments comes at the risk of the environment. An increase in investments leads to an increase in the consumption of energy. As stated by [27], both economic and financial stability will harm the ecosystem if proper policies are not implemented. Thus, ER and FR are anticipated to improve ecological quality: β_5 = LF/ER > 0 and β_6 = LF/FR > 0.

The following economic function is proposed based on the aforementioned theoretical underpinning:

$$LF_{i,t} = f(GDP_{i,t}, GDPS_{i,t}, REC_{i,t}, FF_{i,t}, ER_{i,t}, FR_{i,t}) \quad (1)$$

where LF, GDP, GDPSQ, REC, FF, ER, FR, and ER denote load capacity factor, economic growth, economic growth squared, renewable energy consumption, fossil fuels, economic risk, and financial risk, respectively.

3.2. Data

The study analyzes the 1990–2019 years to explore the effect of country risk and renewable energy consumption on LF for BRICS countries. Economic growth is also considered another driver of LF. The dependent variable is LF, while the regressors are economic growth, renewable energy, economic risk, financial risk, and fossil fuel. The data description is shown in Table 1. The log transformations of the variables are derived to ensure the series conforms to a normal distribution and reduces heteroskedasticity.

Table 1. Data measurement.

Acronym	Variable	Description	Source
LF	Load Capacity Factor	Biocapacity divided by ecological footprint	[65]
GDP	Economic Growth	Per capita Constant 2015	[66]
REN	Renewable Energy	TWh	[67]
ER	Economic Risk	Index	[68]
FR	Financial Risk	Index	[68]
FF	Fossil Fuels	TWh	[67]

Table 2 presents the descriptive statistics. FF ranges from 829.64 to 32,388.7, GDP ranges between 575.50 and 11,993.7, REC (811.66) ranges from 20.558 to 5325.4, FR (37.62) ranges from 16.937 to 48.000, ER (32.361) ranges from 23.983 to 44.875, and LF (1.215) ranges from 0.2176 to 4.4775. Moreover, GDP and ER are negatively skewed, while LF, FF, and REC are positively skewed. The kurtosis values also disclosed that all the variables are leptokurtic except GDP, which is platykurtic. Figure 1 shows the visual information regarding the minimum and maximum of the variables. Furthermore, Figure 2 shows the scatter plot among each variable. Moreover, in Figure 2, the correlation coefficients per each pair of variables are shown.

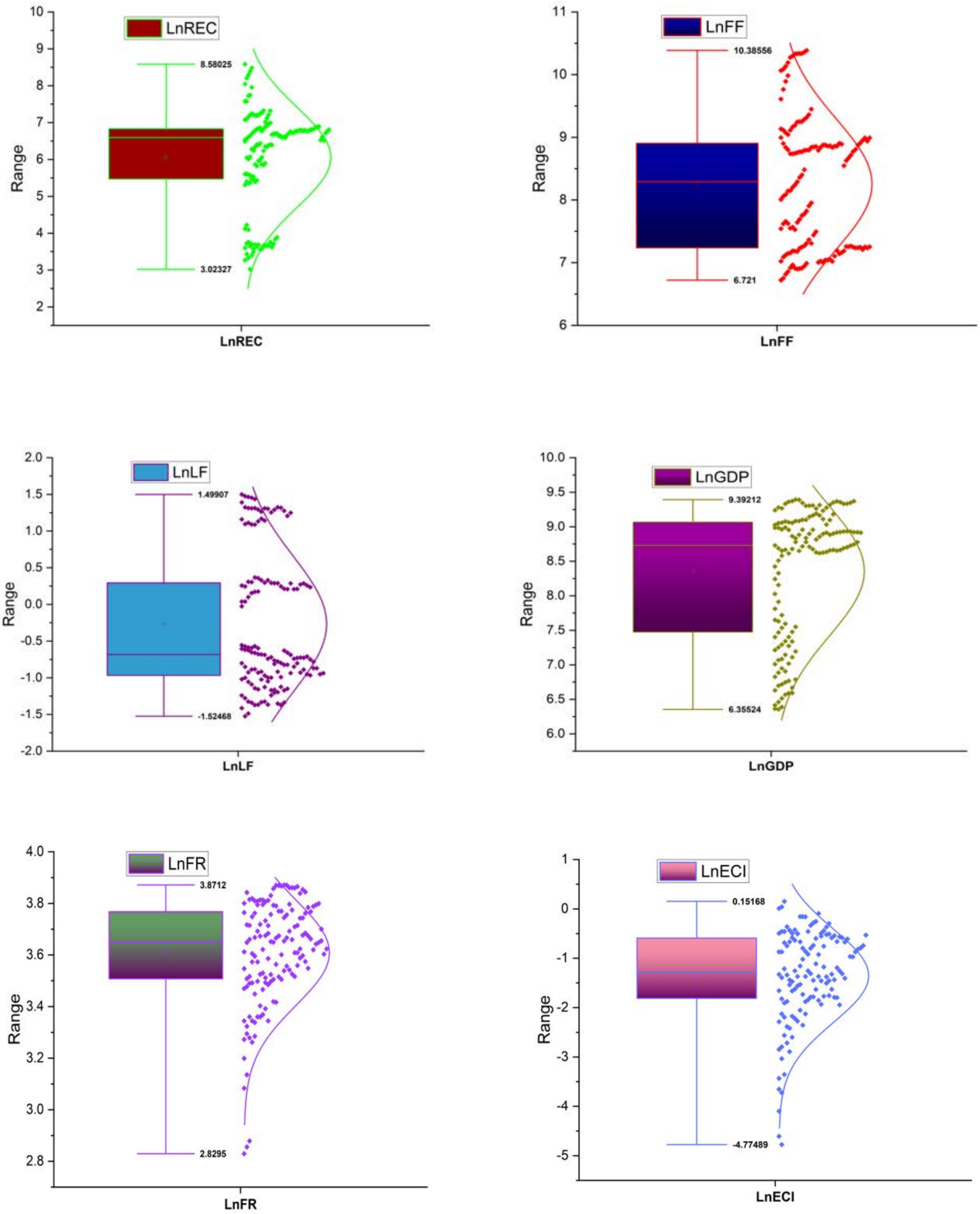

Figure 1. Box Plot.

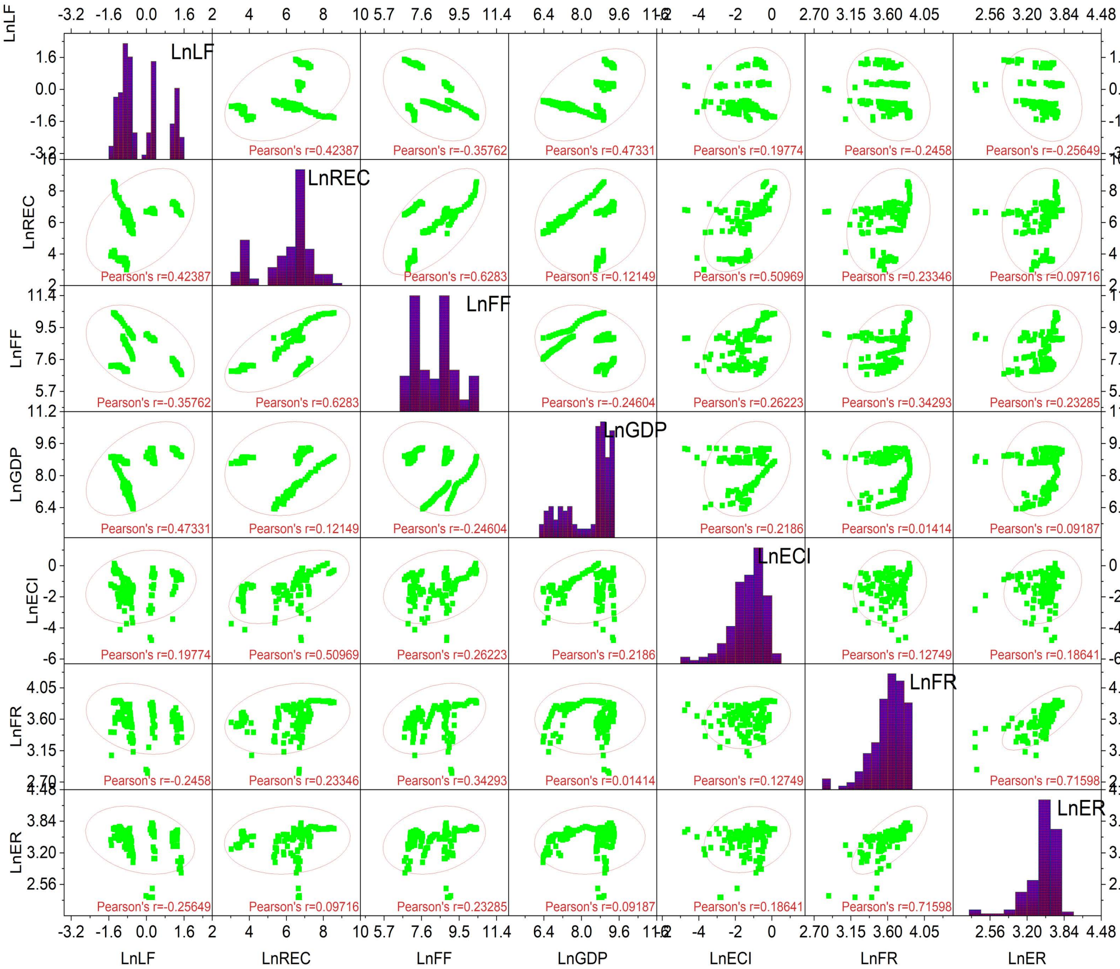

Figure 2. Scatter Plot.

Table 2. Descriptive statistics.

Statistics	LF	FF	REC	GDP	FR	ER
Mean	1.2152	6640.3	811.61	5913.7	37.622	32.363
Median	0.5051	3988.7	731.62	6186.6	38.453	34.001
Max	4.4773	32,388.1	5325.5	11,993.1	48.006	44.875
Min	0.2175	829.65	20.556	575.52	16.936	23.989
Std. Dev.	1.2677	7734.8	887.48	3654.6	6.8877	8.0508
Skewness	1.3334	2.0375	2.7169	−0.0675	−0.6188	−1.5527
Kurtosis	3.2359	6.4783	12.114	1.7433	3.1153	4.0266

Source: Authors' calculations in Stata.

3.3. Empirical Strategy

For the first inspection, the slope heterogeneity test suggested by [69] is performed to ascertain whether the slope coefficients are heterogeneous across different cross-sections. Moreover, we utilized the CD test proposed by [70]. It helps us to understand if first- or second-generation panel unit root tests are more appropriate. The empirical analysis proceeds using Westerlund's cointegration test. This test is more effective than other first-generation tests. The long-run estimators (i.e., FMOLS, FE-OLS, and DOLS) are used to capture the cointegrating relationship among the variables.

3.3.1. Method of Moments Quantile Regression

MMQR is the main empirical approach employed in this empirical analysis. The conditional distribution of LF in the BRICS economies is recorded using the MMQR to account for any variations in LF determinants. Following [42], the conditional quantile of a random parameter $QY(\tau \mid X)$ is illustrated in Equation (2):

$$Y_{it} = \alpha_i + X'_{it}\,\beta + (\delta_i + Z'_{it}\,Y)\,U_{it} \tag{2}$$

Y_{it} represents the dependent variable, while X_{it} is the set of regressors. Moreover, (α, β, δ, Z') denotes the estimated parameters. The probability $P\,\{\delta_i + Z'_{it}\,Y > 0\} = 1$. According to [42], we can write:

$$Q_y\,(\tau \mid X_{it}) = (\alpha_i + \delta_i\,q(\tau)) + X'_{it}\,\beta + Z'_{it}\,Y\,(\tau) \tag{3}$$

where $QY(\mid X_{it})$ represents the quantile distribution of the explanatory component. The scalar coefficient represents Y_{it}. Z describes a k-vector of unrecognized sections of X_{it} that is normalized to fulfill [42] moment constraints $E(U) = 0$ and $E(\mid U \mid) = 1$. MMQR suggested by [42] is also applied. Unlike the long-run estimators, this technique can identify the association between the series at various quantile distributions of LF.

3.3.2. Panel Causality

The FE-OLS, DOLS, FMOLS, and MMQR estimators, which only offer long-run estimates for the variables, cannot indicate the direction of causality. As a consequence, [65] causality test is used. In panel data, the D-H causality test accounts for CD and heterogeneity. The causality equation is as follows:

$$\Delta Y_{it} = \alpha_1 + \sum_{k=1}^{p} \beta_{ij} Y_{it-j} + \sum_{k=0}^{q} \delta_{ij} X_{it-j} + \varepsilon_{it} \tag{4}$$

From Equation (4), i, t, and j denote the cross-sectional unit, time frame, and optimal lags, respectively. X_{it} represents the regressors. Additionally, p and q are optimal lag orders, while the error term is indicated by ε_{it}.

A diagram of the empirical analysis is shown in Figure 3.

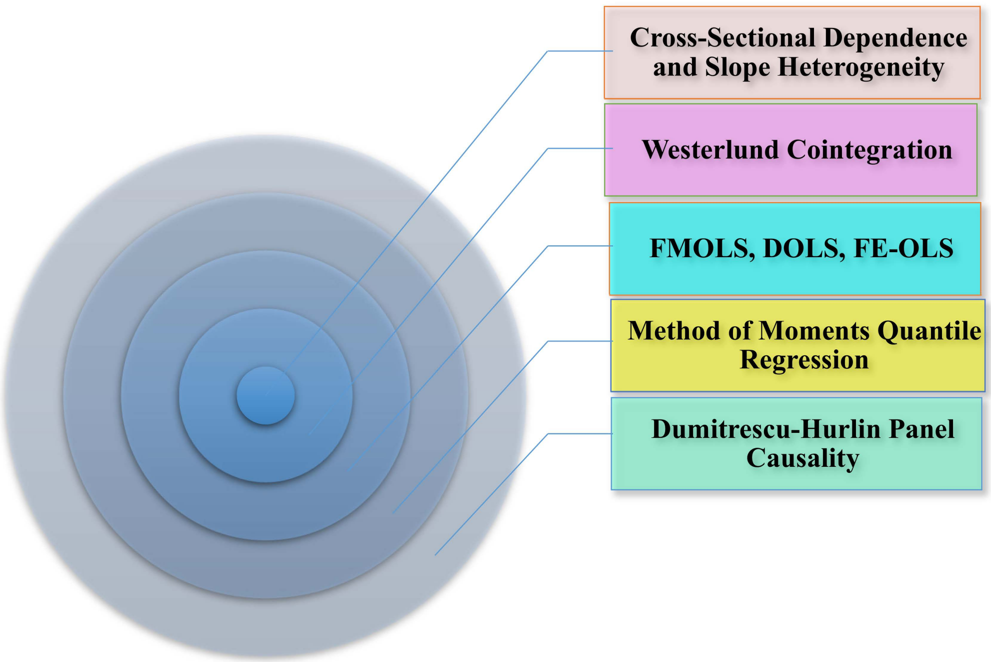

Figure 3. Graphical description of the applied methodology.

4. Findings and Discussions

4.1. Findings and Discussions

We employed the SH test to evaluate the homogeneity of the slope coefficients. The test findings are presented in Table 3; based on the test statistics, the null hypothesis of homogeneous slope coefficients is rejected. Thus, the slope coefficients are heterogeneous across different cross-sections. This demonstrates that applying heterogeneous panel estimation methods is appropriate.

Table 3. Slope Heterogeneity test results.

$\hat{\Delta}$	p-Value	$\hat{\Delta}_{Adj}$	p-Value
10.923 ***	0.000	11.383 ***	0.000

Notes: *** $p < 0.01$.

As previously noted, we employ a range of econometric techniques to effectively address our goals. To this extent, we use the [70] CD dependency test to investigate the CD between various cross-sections. Table 4 provides a list of the CD test results. The findings highlight that we can soundly reject the null hypothesis of no interdependence; consequently, we conclude that CD occurs among the panel.

Table 4. CD, CIPS, and CADF test results.

	CD		CIPS		CADF	
Variable	Level	p-Value	Level	First-Difference	Level	First-Difference
LF	11.733	0.000	2.139	−5.038 ***	−1.926	−4.237 ***
GDP	6.0484	0.000	−1.972	−4.439 ***	−2.034	−5.288 ***
REC	13.031	0.000	−1.284	−4.735 ***	−1.039	−4.747 ***
FF	10.214	0.000	−1.931	−5.156 ***	−1.513	−5.114 ***
FR	8.3645	0.000	−2.118	−4.097 ***	−2.185	−3.965 **
ER	5.5369	0.000	−1.925	−4.829 ***	−1.293	−4.386 ***

Notes: *** $p < 0.01$, ** $p < 0.05$.

The Covariate Augmented Dickey-Fuller (CADF) findings demonstrate that LF, GDP, REC, FF, ER, and FR are nonstationary as a result of the use of second-generation panel unit root techniques in Table 4. However, these variables are stationary at the first-difference. The Cross-sectionally augmented Im-Pesaran-Shin (CIPS) results are also comparable and demonstrate that LF, GDP, REC, FF, ER, and FR are I(1).

4.2. Panel Cointegration Analysis

The long-term relationship among LF, GDP, REC, FF, ER, and FR is then explored. As a result, the [71] approach is used to determine cointegration. The results provided in Table 5 demonstrate the significance of Gt, Ga, and Pa statistics, indicating that the variables LF, GDP, REC, FF, ER, and FR share a long-run relationship.

Table 5. Westerlund's cointegration test results.

Gt	Ga	Pt	Pa
−3.740 ***	−14.182 *	−5.203	−14.593 ***

Notes: *** $p < 0.01$, * $p < 0.10$. Gt, Ga, Pt, and Pa represent the statistics of the cointegration test.

4.3. Long-Run Estimators Results

The long-run elasticities can be measured since cointegration has been detected. Table 6 gives FE-OLS, DOLS, and FMOLS estimates results. First, we uncovered the positive role of GDP in decreasing LF. Specifically, a 1% increase in GDP provokes a statistically significant reduction in LF. Furthermore, GDPSQ impacted LF positively, as expected, confirming the load capacity curve hypothesis. Renewable energy positively affects LF. In particular, a 1% increase in REC raises LF by 0.30–0.59%. Furthermore, the FF effect on LF is negative and significant for all three estimators. The effect of FR on LF is positive for the BRICS nations since a 1% increase in FR generates a significant rise in LF, between 0.27% and 0–40%. Finally, a positive effect of ER on LF is found, showing that a 1% increase in ER generates a significant LF increase, between 0.43% and 0.79%.

Table 6. FMOLS, DOLS, and FE-OLS results.

	FMOLS		DOLS		FE-OLS	
Variable	**Coefficient**	***p*-Value**	**Coefficient**	***p*-Value**	**Coefficient**	***p*-Value**
GDP	−1.645 ***	0.000	−1.383 ***	0.000	−1.294 ***	0.000
GDPSQ	0.736 ***	0.000	0.538 ***	0.000	0.538 ***	0.000
REC	0.303 ***	0.029	0.586 ***	0.000	0.441 ***	0.000
FF	−1.283 ***	0.000	−1.384 *	0.083	−1.227 ***	0.000
FR	0.338 ***	0.000	0.402 *	0.074	0.269 ***	0.000
ER	0.793 ***	0.000	0.503 ***	0.000	0.439 ***	0.000

Notes: *** $p < 0.01$, * $p < 0.10$.

4.4. Method of Moments Quantile Regression Results

Long-run estimators (DOLS, FE-OLS, and FMOLS) can only identify the long-run association among variables; however, they cannot capture the interrelationship in each quantile. Therefore, we employed the MMQR to evaluate the connection between LF and its determinants (see Table 7). In each tail, i.e., 0.1–0.90, the effect of economic growth and its squared term on LF is negative and positive, respectively, suggesting that the economic growth adversely impacts ecological quality at the initial phase; however, after reaching a threshold, economic growth affects ecological quality positively. FMOLS, DOLS, and FE-OLS estimators also report a similar result, suggesting that real growth lessens ecological quality.

Table 7. MMQR results.

		GDP	**GDPSQ**	**REC**	**FF**	**FR**	**ER**
Location		−1.038	0.831 ***	0.403 ***	−1.352 ***	0.749 *	0.504 ***
Scale		−0.938	0.6227 ***	0.311 ***	−0.928 ***	0.648 *	0.668 ***
Low	0.1	−1.082 ***	0.927 ***	0.305 **	−1.373	0.468 **	0.532 ***
	0.2	−1.109 ***	0.836 ***	0.347 **	−1.515	0.515 **	0.559 ***
	0.3	−1.136 ***	0.753 ***	0.389 **	−1.657	0.562 **	0.586 ***
Middle	0.4	−1.163 **	0.702 ***	0.431 *	−1.799	0.639 **	0.613 ***
	0.5	−1.19 **	0.648 ***	0.494 *	−1.941	0.676 *	0.648 **
	0.6	−1.217 **	0.603 **	0.584 *	−2.083	0.713 *	0.666 **
High	0.7	−1.244 **	0.538 **	0.545 *	−2.225	0.756 *	0.693 **
	0.8	−1.271 **	0.468 **	0.594 *	−2.367	0.800 *	0.720 *
	0.9	−1.298 *	0.415 **	0.642	−2.509	0.844 *	0.747 *

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Furthermore, the REC influence on LF is positive and significant across the quantiles; however, the strength of the interrelationship increases across the quantiles. This implies that renewable energy boosts ecological quality across the tails. Conversely, the fossil fuel energy use effect on LF is negative across all tails. In addition, across all the tails, FF intensifies the lessening of the ecosystem. Lastly, the effect of financial and economic risk on LF is positive and significant, which implies that financial and economic risk intensifies ecological quality in each tail. Figure 4 presents the MMQR results.

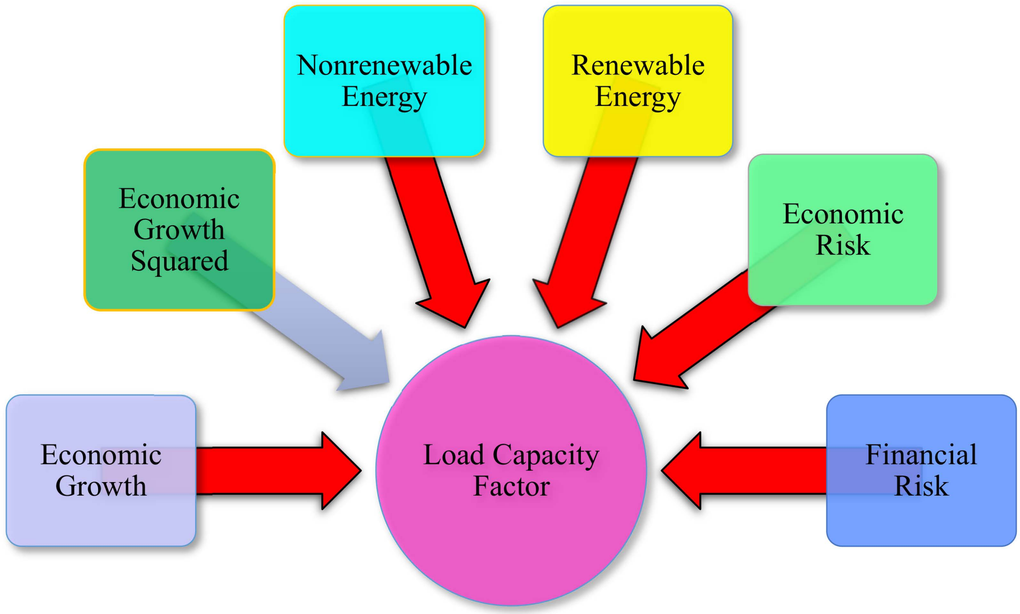

Figure 4. Summary of findings from FMOLS, DOLS, FE-OLS, and MMQR estimators.

4.5. Dumitrescu-Hurlin Panel Causality Results

The presence of CD makes the argument that traditional causality tests are not feasible to produce accurate results. Therefore, the DH causality test is used to assess the direction of the causality among the selected series, and the findings are shown in Table 8. The results reveal that all the independent variables can forecast LF. Thus, ecological quality is affected by GDP, FR, ER, REC, and FF.

Table 8. Dumitrescu-Hurlin panel causality tests results.

Null Hypothesis	W-Stat.	Zbar-Stat.	*p*-Value
GDP ≠ LF	6.6736 ***	7.60205	0.000
LF ≠ GDP	1.8705	1.06629	0.286
FR ≠ LF	9.7745 ***	11.8212	0.000
LF ≠ FR	0.4970	−0.80273	0.422
FF ≠ LF	5.1345 ***	5.50753	0.000
LF ≠ FF	6.217 ***	7.837	0.000
ER ≠ LF	1.5711 ***	2.96543	0.003
LF ≠ ER	1.5856	0.67444	0.500
REC ≠ LF	3.2663 ***	3.62752	0.000
LF ≠ REC	3.7528	0.65468	0.512

Notes: *** $p < 0.01$.

4.6. Discussion of the Empirical Results

The effect of economic growth and economic growth squared on LF is negative and positive, respectively, confirming the load capacity curve hypothesis. The results infer that real growth in the BRICS economies increases ecological deterioration in the initial phase. It might be argued that operations that significantly increase contamination are necessary for the economic growth process of these countries. In fact, these economies are heavily dependent on the use of coal, gasoline, and oil for the generation of energy, which is the prime motivation behind economic operations in the manufacturing and service sectors; therefore, an increase in economic activities will trigger ecological deterioration. To sum up, the growth of ecological damage in the BRICS nations can be linked to the growth trajectory of these countries. This suggests that these economies need to readjust their growth strategies as it negatively affects the quality of the environment. However, after reaching a threshold, an increase in income is expected to promote ecological quality. In the same vein, Ref. [53] reported that the growth pattern of the Nordic economies is harming the ecosystem's health. Likewise, Refs. [72–74] highlighted similar results.

The study also uncovers a positive linkage between ecological quality and ER. This implies that when ER rise, investments in these nations are discouraged following the high level of risk, leading to improved environmental quality. So, BRICS economies are at a higher risk of economic danger due to inferior ecological quality. The components of economic risk specify the flaws and advantages of an economy. Generally, an economy will be less vulnerable when its advantages outweigh its disadvantages. The uncertainty that results from declining investment opportunities and demand, as well as rising price volatility and GDP growth, eventually generate lower energy usage and emissions are supported by [38,39,75].

Moreover, we observed a positive nexus between FR and ecological quality, which means that an increase in FR deters investments due to the risk level in these countries, finally provoking an improvement in ecological quality. FR assesses a country's ability to finance the activities of its government. This result might be rationally attributed to the reality that nations with fewer financial risks are more effective and able to draw more Foreign Direct Investments (FDIs) [56]. In addition, the flow of economic activities in less dangerous economies is smoother and more efficient than it is in high-financial-risk states; having a stable financial scenario might promote the financing of the advancement of green technology, resulting in a major improvement in ecological quality and energy efficiency. Consequently, nations and firms cut their energy use and costs, reducing environmental harm. Such a result is consistent with [27,28,76], who stated that higher ecological quality is correlated with FR.

Furthermore, FF impacts ecological quality negatively. This result strengthened the notion that most emerging economies are fueled by FF-based energy, which is dirty and threatens the environment. Ref. [54] pinpointed that the economic expansion in the BRICS nations is facilitated by dirty energies, which also contribute to ecological damage. Ref. [55] documented a similar result regarding the nexus between FF and CO_2 emissions. The same view is also supported by [16] for the UK. Moreover, renewable energy impacts ecological quality positively. The advancement of sustainable energy still remains largely dependent on technological innovations. Research, demonstration, development, and deployment are the hallmarks of the innovation processes for renewable energy technologies, which are also common to other technologies. There is also ongoing learning and a variety of dynamic feedback mechanisms between these phases [54].

A transition to sustainable energy is made possible by technological advancement in a number of ways. Since it is more expensive than fossil fuels, clean energy has hitherto been far less marketed [15], although technical advancement in this area might encourage investment in renewable energy [77,78]. Clean energy costs are falling as technology for producing it becomes more advanced, and the market share that it currently holds is growing. Reasonably, renewable energy is expected to enhance the environment. The use of renewable energy has been suggested as the solution to energy transition in the recent

COP-27 in Egypt as well as the COP-26 in Scotland. The investigation of [1] in BRICS economies using the MMQR reported comparable results by highlighting the emissions-mitigating role of renewable energy. Likewise, [79–82] documented that REC growth helps curb CO_2 emissions. In the same vein, the policy towards renewable energy adoption should be initiated in order to attain carbon neutrality targets [82–87].

5. Conclusions and Policy Recommendations

5.1. Conclusions

The urgent need for environmental sustainability among scholars, policymakers, and various intergovernmental organizations is a worldwide issue. Therefore, this research shed light on the knowledge of climate change by analyzing the effects of energy consumption and country risks on the load capacity factor (a proxy for ecological quality) in the BRICS countries over the years 1990–2018. To the best of our knowledge, this analysis is the first to assess how the country's risk and energy consumption affect the LF for this area. The current study applies several second-generation panel techniques. For the unit root test, the study employs both the CIPS and CADF unit root tests, while Westerlund's cointegration is used to evaluate the existence of a long-run relationship among the variables. Furthermore, FMOLS, FE-OLS, and DOLS estimators are employed to evaluate the effect of the independent variables on LF. Moreover, the relationship in each quantile was evaluated using the MMQR. Finally, the D-H panel causality test was utilized to inspect the causal link between the load capacity factor and the regressors. In general, empirical results highlight that: (i) the series are I(1); (ii) the existence of a cointegrating relation is found; (iii) FF and economic growth cause LF to decline, while economic risk and the use of renewable energy sources increase LF; (iv) the conclusions of the MMQR estimates are broadly supported by the outcomes of the DOLS, FMOLS, and FE-OLS methodologies; and (v) the causality results demonstrate that these factors may forecast ecological quality, indicating that policies for renewable energy consumption, financial risk, renewable energy, and economic growth can all have an impact on the degree of LF.

5.2. Policy Recommendations

The primary driver of economic expansion in the BRICS countries is the use of environmentally harmful fossil fuels. Climate change is one of the issues threatening the livelihoods of several people in emerging nations due to the use of fossil fuel-based energy sources. Focusing on structural transformation and developing clean energy is essential to reducing the harmful effects on the environment. Thus, the research's findings may be used to offer a number of policy recommendations.

- First, policymakers and scholars in this area should focus on resolving the root causes of environmental deterioration that stem from economic development, such as insufficient ecological deterioration abatement technology and lax ecological regulation legislation. Emission-lessening technology should be developed and strict environmental regulations put in place to reduce environmental damage. Governments should be obliged to adopt severe actions if consumers and firms disregard the policy directives to improve ecological quality.
- Second, policymakers need to support the economic growth process while maintaining sustainable development to meet a certain risk threshold and reduce environmental harm. Governments must wholeheartedly support expenditures on environmentally friendly technology and financial and economic stability to increase energy efficiency and promote the implementation and use of energy-saving goods. Additionally, governments should consider the implications of economic and financial risks before announcing any energy or environmental policy.
- Third, government funding for R&D is required in the BRICS nations. It is crucial to acknowledge the business sector's contribution in this respect. Household surveys must be utilized to analyze public opinions of renewable energy sources in order to make effective policy decisions. It is crucial to determine which renewable energy

source, out of the others, they prefer the best. As an example, there has been an increase in the use of solar panels recently. Promoting businesses that use solar power for manufacturing is a good strategy. Households should also be allowed to get modest loans simultaneously to buy solar panels. The use of renewable energy sources should be emphasized in the message to help people realize the importance of cleaner energy.
- Fourth, subsidies for the exploration, usage, and production of fossil fuels should be gradually eliminated. The shift to low-carbon technology and the reduction of CO_2 emissions can be facilitated by shifting these incentives towards renewable energy sources and energy efficiency initiatives.

5.3. Limitations of the Study and Future Directions

This study seeks to assess the impact of energy, economic risk, and globalization on ecological quality using a thorough empirical methodology. It does, however, have significant shortcomings. First of all, this analysis is limited to the BRICS countries. For a thorough overview, a new study might thus either concentrate on other emerging or developed nations. Second, only financial and economic risks are taken into account in this analysis. New studies may thus take into account political risk and conduct far more in-depth investigations. Third, due to data availability restrictions on the load capacity factor, this analysis employs data from 1990–2018; therefore, subsequent research can only concentrate on CO_2 emissions and use more recent data.

Finally, the current war between Russia and Ukraine raises some caution. Russia faces a deep financial and economic recession, which puts significant pressure on policymakers to focus on short-term economic recovery measures rather than long-term environmental sustainability goals. The Russian government has prioritized economic growth, which has resulted in an increased focus on oil and gas production, a significant contributor to environmental degradation. Additionally, the Russian government has historically been skeptical of environmental policies that could potentially harm the country's economic interests [33,88]. The government has favored a centralized approach to environmental decision-making, which has resulted in a lack of public participation and transparency in environmental policy development. Moreover, the current political climate in Russia does not prioritize environmental policies, and the government's response to environmental issues has been relatively weak compared to other countries. Furthermore, the implementation of the recommendations would require significant investment in renewable energy technology, which may not be feasible given the current economic situation in Russia [89]. The country has significant reserves of oil and gas, which are essential to its economy. Therefore, the government may not be willing to invest in alternative energy sources, which could potentially weaken its economic interests.

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