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Geopolitical risks and natural resources rents: Evidence from BRICs countries

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Abstract

The purpose of this study is to examine the impact of geopolitical risks on natural resource rents in BRICS countries. The current study uses wavelet analysis to examine the relationship between geopolitical risks and natural resource rents in BRICS (China, India, Russia, Brazil, and South Africa) economies over time-frequency space from 1990 to 2020. The wavelet-based analysis results reveal that the co-movement between natural resource rents and geopolitical instability in BRICS countries appears to be changing simultaneously over different time periods and different frequencies. More importantly, our empirical results highlight that these geopolitical risks negatively impact natural resource rents at medium and low frequencies in China, India, Russia, and Brazil, while geopolitical risks positively impact natural resource rents in South Africa over the sample period. From the research results, some policy implications related to sustainable development or conservation of natural resources for future generations are suggested.

Keywords: BRICS countries, geopolitical risks, natural resource rents, wavelet analysis.

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1. Introduction

Trade integration and globalization have increased the importance of the debate over geopolitical risks (GPR) and natural resource rents (NAR) [1]. Rising commodity prices signify affluent economies and rising revenue, which can result in increased consumption, investment, productivity, and financial liquidity. The rising incidences of state/regional instability, terror attacks, and other negative geopolitical scenarios around the globe have increased geopolitical uncertainty. The consequent geopolitical conflicts have not only resulted in the direct destruction of human lives, but they also influence economic relationship preferences [2]. Specifically, global economic development is reliant on natural resources and fossil fuels because natural resources are powerful variables that rely on the effectiveness of finance and its inclusion into commodity prices [3]. We formulate a sound research question about how geopolitical risks affect natural resources rents in BRICS economies in light of this context.

Geopolitical uncertainty is recognized as a primary driver of financial market performance and energy markets and a key factor in investment decision-making by traders and market managers [4, 5]. In addition, the influence of GPR on natural resources and fundamental macroeconomic indicators has received remarkable attention in the past [6, 7]. As a result, this article explores the time and frequency relationship between GPR and NAR in the BRICS countries, which are the emerging economies as well as the biggest oil importers in the world. More importantly, under their quick urbanization and industrialization processes, the BRICS nations have retained a strong demand for natural resources and have been dependent on imports, which brings significant issues in terms of availability and diversity, price and equity, technology and efficiency, and environmental sustainability [1].

The BRICS economies are chosen because they demonstrate the concerns and worries of the emerging world in the current international geopolitical environment and are the largest in the world [5]. Furthermore, the BRICS make up 42% of the global population, 23% of global GDP, 30% of territory, and 18% of global trade [1]. Empirical research on natural resources, transition of energy, and GPR in the BRICS provides a powerful inference that can help with stable energy market and a smooth transition from traditional energy sources to the clean energy sector that is shaped by many other emerging and developing economies. Up to now, GPR in the BRICS countries have escalated, and empirical findings can aid in better managing the BRICS economies' interests and the rest of the globe [8]. Therefore, understanding the significance of GPR for natural resources rents in these countries is necessary for designing policies and decision-making.

The extensive literature on the interplay between GPR and NAR has mixed results [9]. The literature suggests the significance of NAR and geopolitical risks for energy and environmental outcomes [5]. Nevertheless, these articles primarily center on country-specific evidence [1]. Also, they mainly concentrate on the transition of energy and deployment while ignoring the natural resources consequences of geopolitical uncertainty. Both empirical and theoretical estimations have taken into consideration the influence of NAR on economic development [10]. The first strand of literature indicates that economic development considerably rises in response to higher natural resources [11]. The other strand suggests a negative interaction between natural resources and economic development since rent-seeking activities increase as a result of resource reliance, which has a negative effect on growth and development results [3, 12]. However, past studies have ignored another fundamental that can predict changes in natural resources is geopolitical uncertainties [9]. Global and local economic connections are increasingly being shaped by geopolitical risks, which directly impact both human life and the economic sphere of the world. Natural resources rents fluctuate due to varying conditions of supply and demand caused by risk and uncertainty. Different outcomes are predicted by theoretical linkages between geopolitical risk and natural resource rents, including negative nexus [9, 13]. Positive interaction between the two indicators [5, 14]. As a result, this study sparks a new discussion in the fields of geopolitical economy and the economics of natural resources.

Put differently, this study empirically investigates the theoretical possibility of co-movement between geopolitical risks and natural resources rents in BRICS economies in a time-frequency space. In the literature, there has been a lot of discussion about how NAR and GPR interact. However, the most widely used methodology in the literature to assess how these indicators interact is the conventional OLS regression [7]. Recently, more complicated time series approaches in the time domain, like VAR, VECM, ARDL, NARDL, and Granger causality, have been employed, but these models are limited to one or, at most two-time scales (long and short-term). In such contexts, wavelet frameworks seem to be a very appealing alternative because the strength and direction of the relationship between GPR and NAR indicators may change with time. Specifically, several complementary wavelet-based techniques are used; namely, the cross wavelet transforms, wavelet coherence, the wavelet cohesion technique of Rua [15] the wavelet-based Granger causality framework of Olayeni [16] and the spectral Granger-causality test of Breitung and Candelon [17]. The capacity of wavelets to decompose any signal into its time-scale elements is their primary advantage. These frameworks can determine whether the lead-lag relationship between variables and the direction and strength of Granger causality change over time and at different frequencies. The key research question of this study is whether, and if so how, the link between GPR and NAR differs over investment horizons in BRICS countries.

Given everything mentioned above, it is easy to assume that there is a longer-term relationship between economic instability and the availability of natural resources. However, four questions must be addressed: (i) Does the lead lag between the NAR and GPR fluctuate in direction and intensity differently over various time scales? (ii) How can economic shocks and uncertain occurrences affect NAR in BRIC nations? (iii) How do these lead-lag connections alter across different geographical regions? And how do Granger-causality tests change across different time and frequencies?

Therefore, our study significantly contributes to the extant literature on the risk-resources relationship. First, to the best of our knowledge, no other study has examined the nexus between geopolitical uncertainty and natural resources rents in BRICS economies using wavelet analysis, which allows us to capture the intercorrelation between GPR and NAR in time and frequency domains, promoting our understanding of possible dependence. Our findings would have significant policy implications for governments and policymakers in the BRICS region. Second, this study establishes a link between geopolitical risks and rents in the developing world, as well as estimates the unique role of geopolitical uncertainty in influencing natural resources rents. Third, we use the wavelet-based Granger-causality test developed by Olayeni [16] to account for regime-switching in the causal association. Wavelet analysis offers strong evidence for or against causal relationships between variables under consideration without taking into account issues like stationary or non-stationary data and the existence or absence of long-run relationships, in contrast to traditional Granger causality tests, which call for pre-testing for unit roots and cointegration. More importantly, we found a statistically significant extreme Granger causality impact in the frequency domain, even though the effect co-moved over time, which was consistent with the wavelet analysis results. Our conclusions are relevant to worldwide investment initiatives, national governments, political analysts, experts in the environment, economists specializing in energy, geologists, officials from the central bank, and financial policy experts.

Both scholarly and policy attention are needed to manage development initiatives in the face of unpredictable energy policies and rising geopolitical dangers.

The rest of the paper is structured as follows: The literature review is extensively discussed in Section 2. Section 3 represents methodology and data. Section 4 presents the empirical results. Section 5 provides the concluding remarks with several policy implications.

2. Literature Review

The literature is extensive in connection with natural resources and geopolitical uncertainty, which the current study represents and discusses in this section. The changes in geopolitical risks in countries such as Brazil, China, Russia, India, and South Africa are extremely crucial for the maintainability of natural commodity prices [3, 18]. The literature on geopolitical uncertainties and natural resources rents is able to be divided into four strands, including the negative, positive, and insignificant influence of geopolitical uncertainties on natural resources rents [6]. More specifically, instead of focusing on natural resources, the fourth body of research examined how geopolitical risks affected overall economic activity [14, 19].

Li, et al. [3] look into the effect of green finance, economic fundamentals, and geopolitical risks on natural resources in China, India, Russia, Canada, and Saudi Arabia and document that there is a negative relationship between NAR and GPR in these economies. Based on this, Sweidan and Elbargathi [12] also reveal that geopolitical risks have a negative impact on natural resources in Saudi Arabia's economy. Geopolitical risks, according to Qin, et al. [13] have no impact on gas returns but have a large negative impact on crude oil returns in bearish markets and heating oil returns in normal and bullish markets. Lee, et al. [8] state that there is a unidirectional Granger causality at the extreme quantiles between geopolitical risk and oil price. Li, et al. [18] also indicate that geopolitical risks have a negative effect on the import and export of the energy trade, and the export restriction is bigger than the import.

Increasing geopolitical risks remarkably reduce the rents from natural resources when they need to be accurately managed. The economies such as China, South Africa, Russia, India and Brazil have the same geopolitical uncertainty and management toward natural resource commodity prices. A recent study by Deng, et al. [20] has examined the nexus between natural resources and the economic performance of BRICS countries during the period 1990–2020. Using panel quantile regression, the findings suggest that there is a unidirectional causality running from natural resources rents to economic uncertainty. Another study by Ma, et al. [21] uncovers that the natural resources rents are more vulnerable than the economic performance in China during the COVID-19 outbreak. In addition, their wavelet results indicate that a bidirectional causality exists between the two indicators at various time and frequency domains. Islam, et al. [7] discover a considerable effect of deconstructed measures of GPR on mineral imports and mineral import-augmented renewable energy generation in China, primarily at the extreme quantiles with long memories. According to Wang, et al. [1] the time-varying relationship between GPR and crude oil security in China is discovered in various quarters within a one-year period. Similarly, Song, et al. [4] analyze the asymmetric impact of geopolitical risks on energy use and environmental degradation in BRICS countries and find that a negative and positive change in GPR has a negative influence on energy consumption in India, China, and Brazil in the long run.

In recent years, Dramani, et al. [19] have highlighted the threshold effects of NAR on GDP in SSA countries and provided evidence of a double threshold effect of NAR on GDP. Using the same method, Sini, et al. [14] conclude that natural resources significantly positively impact violence in 54 African nations. Su, et al. [22] evaluate the causal association between GPR, oil prices, and financial liquidity using a wavelet framework. Their results unveil that GPR has a significant impact on financial liquidity and oil prices at different time and frequencies in Saudi Arabia. In the same vein, Khan, et al. [23] confirm that geopolitical risks lead oil prices in the medium run and have a positive impact on financial liquidity in the Kingdom of Saudi Arabi. Yang, et al. [24] use a time-varying copula model to shed light on the risk transmissions from the GPR to green energy stock exchanges. Their findings uncover that there are considerable risk transmissions from GPR to renewable energy markets, and the risk transmissions do not witness a clear negative or positive pattern. These results are consistent with Cai and Wu [25]. Figueiredo, et al. [26] also conclude that GPR has negative effects on both the corporate sectors of energy and other industries. Ajide, et al. [27] reveal that NAR has significant impacts on transnational terrorism, and domestic and global anti-terrorism measures are negatively marginally impacted by the combination of NAR and anocracy.

The economic aspects of geopolitical uncertainty are typically the subject of empirical research. For example, Rasoulinezhad, et al. [28] analyze energy transition patterns in Russia with the role of GPR and document a long-term positive influence of GPR on energy transition. Li, et al. [29] investigate the time-frequency relationship between GPR and oil prices and report a high degree of co-movement between GPR and oil prices in the short run. Alqahtani and Taillard [30] suggest that oil prices do not respond to shocks in geopolitical risk, and GPR does not cause oil returns in the long run. Shen, et al. [11] report that GPR substantially encourages mergers and acquisitions, and it significantly benefits M&A via potential mechanisms involving the real option and prospect synergy impact. Flouros, et al. [31] argue that GPR has a significantly considerable impact on both the short and the long run of green investments. Sweidan [32] demonstrates that geopolitical risk encourages governments to be self-sufficient and rely on renewable energy sources to mitigate the fossil fuel inflows' risk.

The above literature review suggests that although linear and non-linear estimation approaches like panel data, ARDL, VAR, Granger causality, NARDL, and threshold models have been used to explore whether geopolitical risks drive or drag natural resources rents for various nations and regions and for different periods and have provided empirical evidence of their diverse outcomes, such evidence is limited for BRICS countries. As a result, this study empirically investigates the time-frequency relationship and causality between geopolitical risks and natural resources rents in BRICS economies for the first

time. In light of the vacancy of current study methodologies, a variety of wavelet frameworks and spectral Granger causality tests are introduced to discuss the nexus between the two indicators from the insight of different time and frequencies.

3. Methodology

3.1. Wavelet Methodology

3.1.1. Continuous Wavelet Transform

We can investigate the joint behavior of time series for both frequency and time using the continuous wavelet transform $W_x(s)$. The wavelet can be expressed:

$$W_x(s) = \int_{-\infty}^{\infty} x(t) \frac{1}{\sqrt{s}} \psi^* \left(\frac{t}{s} \right) \quad (1)$$

where * denotes the complex conjugate and the s shows scale parameter, which identifies whether the wavelet can detect higher or lower elements of the series $x(t)$.

3.1.2. Wavelet Coherence

The wavelet coherence is computed based on the cross-wavelet transform and wavelet power spectrum of time series. The cross-wavelet of two series $x(t)$ and $y(t)$ can be defined as:

$$W_n^{XY}(u,s) = W_n^X(s,\tau) W_n^{Y*}(s,\tau) \quad (2)$$

where s is the scale, * represents the complex conjugate, and u presents the position. Therefore, the wavelet coherence can be written as follows:

$$R_n^2(s,\tau) = \frac{|S\left(s^{-1} W_n^{XY}(s,\tau)\right)|^2)}{S\left(s^{-1}|W_X(s,\tau)|^2\right) S\left(s^{-1}|W_Y(s,\tau)|^2\right)} \quad (3)$$

where S denotes a simultaneous process of temporal and frequency smoothing.

$R_n^2(s,\tau)$ is in the range $0 \le R^2(s,\tau) \le 1$.

3.2. Wavelet Correlation

The wavelet correlation measure from Rua [15] is given by:

$$\rho_{XY}(s,\tau) = \frac{\xi\left\{s^{-1}|\Re\left(W_{XY}^m(s,\tau)\right)|\right\}}{\xi\left\{s^{-1}\sqrt{|W_X^m(s,\tau)|^2}\right\}.\xi\left\{s^{-1}\sqrt{|W_Y^m(s,\tau)|^2}\right\}} \quad (4)$$

To set the stage for the unintentional relationship between variables.

where $\xi(Q) = \xi_{scale}\left(\xi_{time}(Q)\right)$ with ξ_{scale} as the smoothing operator along scale axis, while ξ_{time} as the smoothing operator along the time axis.

3.3. Causality in Continuous Wavelet Transform

Olayeni [16] created the continuous wavelet transform for Granger causality, which expands the CWT-based correlation developed by Rua [15]. It can be written as

$$G_{Y\to X}(s,\tau) = \frac{\xi\left\{s^{-1}|\Re\left(W_{XY}^m(s,\tau)\right) I_{Y\to X}(s,\tau)|\right\}}{\xi\left\{s^{-1}\sqrt{|W_X^m(s,\tau)|^2}\right\}\xi\left\{s^{-1}\sqrt{|W_Y^m(s,\tau)|^2}\right\}} \quad (5)$$

where $W_Y^m(s,\tau)$, $W_X^m(s,\tau)$ and $W_{XY}^m(s,\tau)$ are the wavelet transformations and $I_{Y\to X}(s,\tau)$ as the indicator function which is defined as

$$I_{Y\to X}(s,\tau) = \begin{cases} 1, & if\ \phi_{XY}(s,\tau) \in (0,\pi/2) \cup (-\pi,-\pi/2) \\ 0, & otherwise \end{cases} \quad (6)$$

3.4. Data

Dogan, et al. [9] unveil that natural resources rents (NAR) have significant interactions with geopolitical risks (GPR) in many parts of the world. As a result, this study also uses total natural resources rents to capture natural resources volatility in BRICS economies. NAR is the sum of oil rents, natural gas rents, coal rents, mineral rents, and forest rents which are measured in per capita (constant $2010). In addition, the historical risk index proposed by Caldara and Iacoviello Caldara and Iacoviello [33] has been utilized as a proxy to construct an index of geopolitical risk for each BRICS country. Our research covers the monthly data for the examined indicators between 1990 and 2020 for BRICS countries, subject to data availability. Our sample stops at the end of 2020 because the data for NAR are available up to 2020. All data are collected from World Bank. Monthly data is beneficial because the findings are based on an increased number of observations, allowing

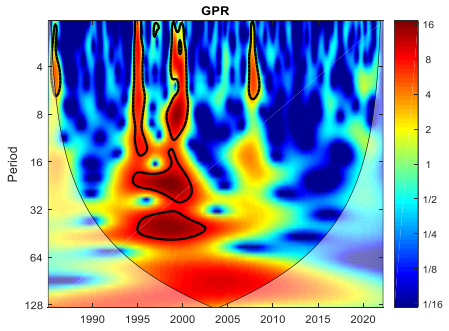
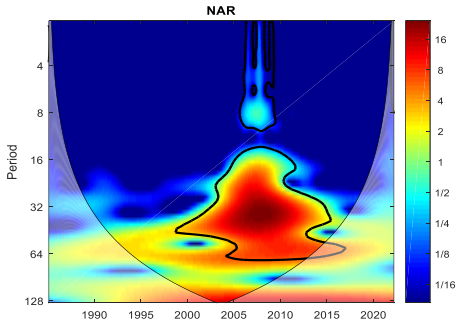
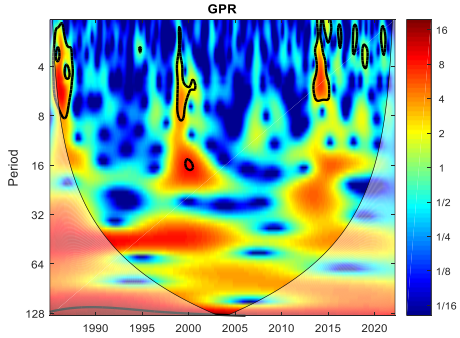
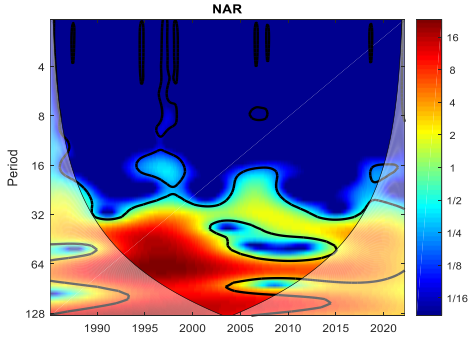
for the evolution of the two variables to be estimated during the research period [34]. Specifically, the nations are chosen based on their positions as the most productive or consumers of natural resources in the world [19].

Table 1.
Results of descriptive statistics.

Variable	Mean	Median	Maximum	Minimum	Std. Dev	Skewness	Kurtosis	Jarque-Bera
Brazil								
GPR	0.043588	0.035608	0.261137	0.000000	0.036837	2.490087	12.20724	1698.420***
NAR	0.236958	0.224816	0.657972	0.070464	0.098152	0.606738	4.141494	43.02075***
Russia								
GPR	0.694432	0.586759	2.831621	0.204862	0.374789	1.772758	7.760913	546.1732***
NAR	1.092837	1.125732	1.939306	0.315532	0.392088	-0.044172	1.888923	19.25562***
India								
GPR	0.199437	0.171266	1.125609	0.044387	0.134782	3.420278	18.60879	4501.627***
NAR	0.244526	0.206417	0.615218	0.132788	0.100277	1.625139	5.806921	285.8683***
China								
GPR	0.412685	0.373074	1.396608	0.084388	0.213353	1.369628	5.385503	204.5092***
NAR	0.306268	0.256038	0.847367	0.079573	0.189833	0.947114	3.185781	56.15056***
South Africa								
GPR	0.051897	0.045347	0.227551	0.000000	0.037370	1.200494	4.806220	139.9212***
NAR	0.367448	0.342488	0.936366	0.173427	0.136490	1.874263	8.107690	622.1693***

Note: *,**,*** represent the significance level at 10%, 5% and 1% respectively.

Table 1 documents the descriptive statistics of both variables examined. Concerning the mean and median values of GPR, they range from 0.0435 in Brazil to 0.4126 in China, which suggests that the GPR in China is relatable to the highly geopolitical risks of the BRICS countries. On the other hand, NAR in Russia has the highest mean, followed by South Africa, China, India, and Brazil. The standard deviation indicates that the unconditional volatility of GPR in China is higher than that of the rest of the countries under investigation. Similarly, NAR in South Africa and India are the most unstable compared with other countries. GPR and NAR in BRICS economies are positively skewed. The Jarque-Bera test outcomes highlight that the concerned variables do not have a normal distribution at the 1% significance level, which in turn recommends the appropriateness and necessity of the wavelet analysis.

INDIA		
RUSSIA		

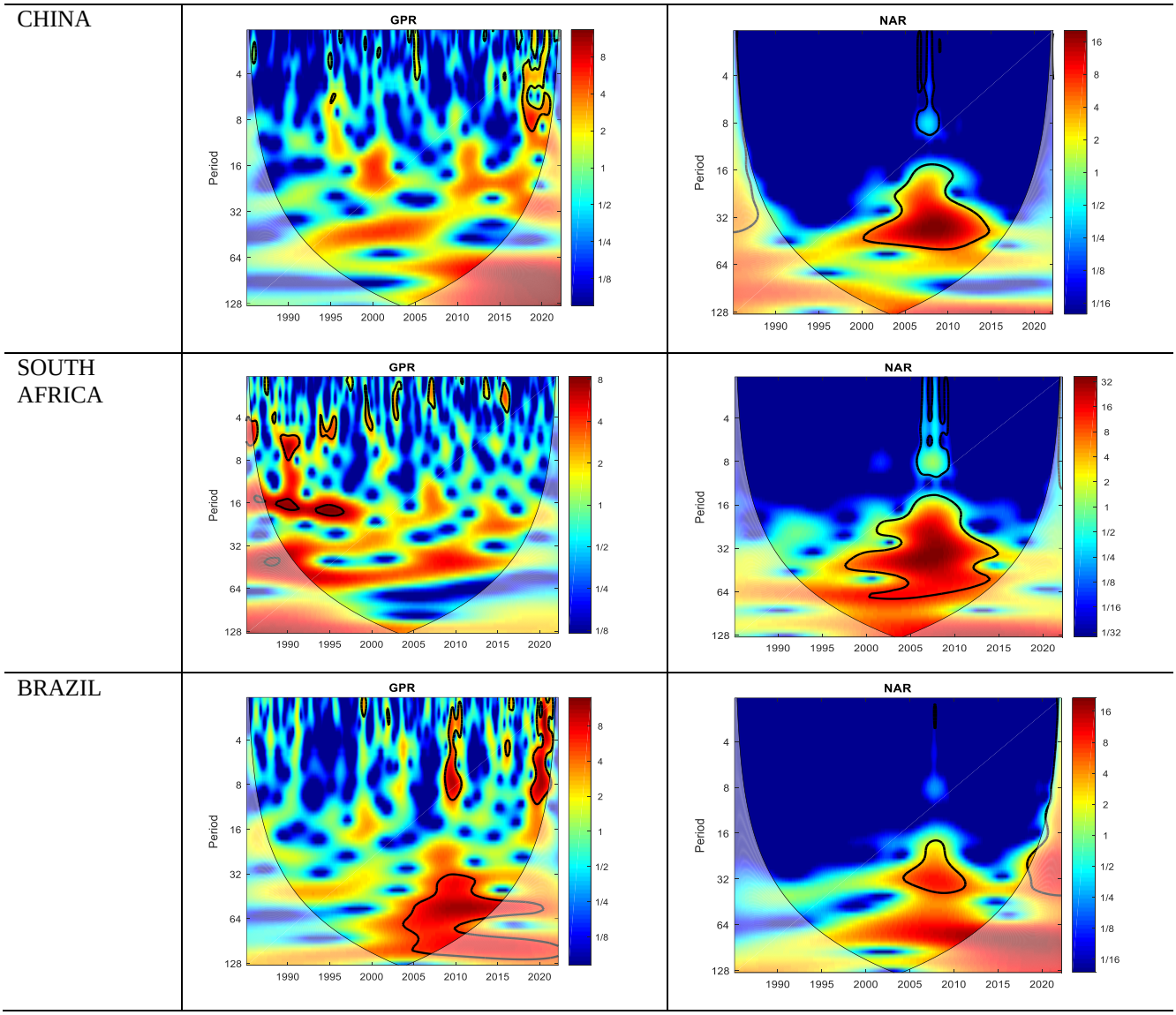


Figure 1.
Continuous Wavelet Transform of NAR and GPR.

Figure 1 describes the continuous wavelet transform power spectrum (CWT) of geopolitical risks and natural resources rents in BRICS nations at different time and frequencies through a three-dimensional contour plot. In Figure 2, we analyze monthly data, where the vertical, and horizontal axes show time and frequency, respectively. The contours that are shaded represent areas that are significant at the 5% level. The zone influenced by edge effects is indicated by the cone of influence, which is represented by a solid curving line. High (low) power is indicated by warmer (colder) colour tones. As per the time-scale decomposition of natural resources rents in Figure 1, most of the indicators reacted to medium and long-run shocks during the sample period. For geopolitical risks, it is apparent that power dramatically rose from 2010 to 2020 over the short-, medium-, and long-term scales, implying that GPR variance was higher at these frequencies over the period shown. More importantly, for India, South Africa, Brazil, and Russia, higher frequencies had more power than lower ones.

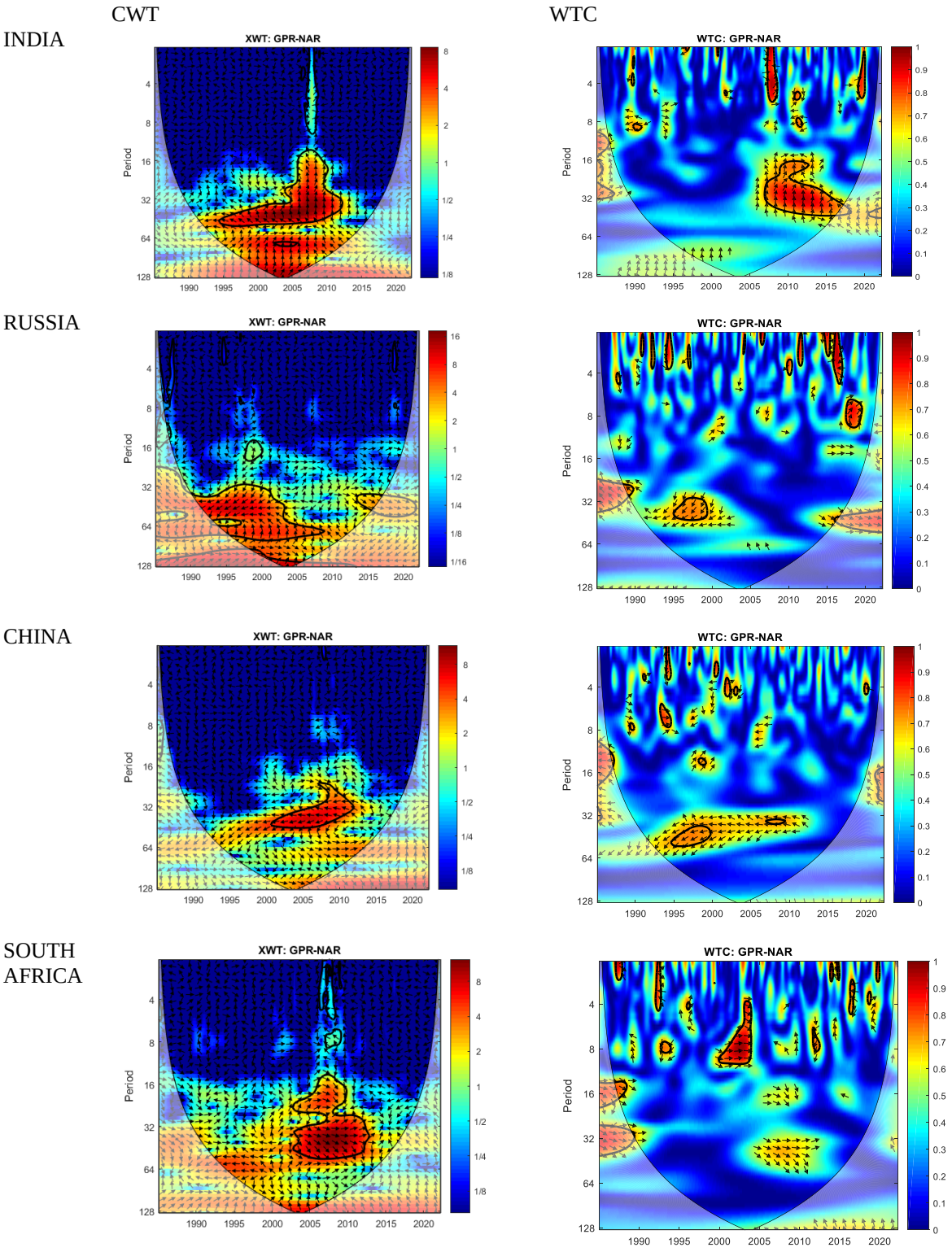
4. Research Results

4.1. Empirical Results

When we apply the wavelet approach to our dataset, we get four different sets of findings: cross-wavelet transforms, wavelet coherence, wavelet correlation, and wavelet-based Granger causality tests; results on the interplay between GPR and NAR in the BRICS economies.

Figure 2 shows the cross wavelet transform (XWT) and wavelet coherence (WTC) for GPR and NAR in BRICS countries. The XWT between the two variables is presented on the left-hand side of Figure 3, reflecting the linear covariance between GPR and NAR at different time and frequencies. These graphs suggest that co-variance gradually raised with scale, revealing that the interplay between GPR and NAR in these nations was more impacted by medium-and long-run and existent changes than by short-lived shocks. A specific time period (2005–2010) and specific frequencies (low) can be determined when XWT was particularly high in all countries. The results also reveal that the direction of the arrows across various scales and over the period was not similar between the pairs of GPR and NAR for each of the BRICS economies. We observe that GPR and NAR are in phase in India at medium and long-term frequencies, the arrows are towards the right up, which indicates

GPR is leading. Nevertheless, from 1995 to 2015, we note that the arrows are towards the left-up, which indicates NAR is leading in China, South Africa, Russia and Brazil. Therefore, we can conclude that there is a clear pattern of lead-lag associations in the BRICS economies. The common power of two series is in fact, explained by the XWT without normalization to the single wavelet power spectrum. This can occasionally lead to ambiguous results because, if one of the spectra is local and the other one exhibits a very high jump, the jump produced in the cross-spectrum, which is a multiplication of the continuous wavelet transformation of two series, cannot be attributed to the relationship between the two series [35]. As a result, wavelet coherency is also used in our analysis. The findings of WTC are represented on the right-hand side of Figure 2.



BRAZIL

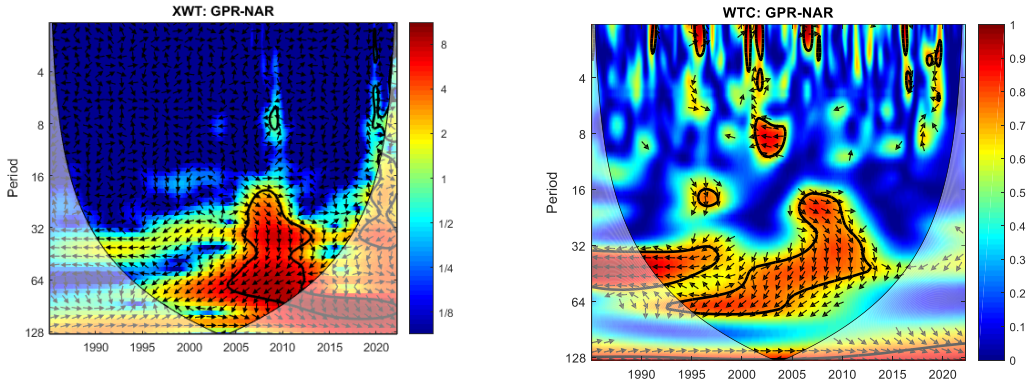


Figure 2.
Cross-wavelets and wavelet coherence between GPR and NAR in BRICS economies.

Figure 2 depicts the estimated WTC and phase difference for the geopolitical risks and natural resources rents in BRICS countries, highlighting evidence of time-varying interaction between these variables across various frequencies and through time. In Figure 2, the short, medium, long, and very long periods are denoted by the numbers 0-4, 4-16, 16-64, and 64-128. Additionally, the colour codes, ranging from red to blue, indicate high and low dependency between GPR and NAR. The right-ward and left-ward arrows denote in-phase and out-of-phase relationships. Specifically, left-down (right-up) arrows suggest that the second variable leads (causes) the first one, whereas left-up (right-down) arrows demonstrate that the first indicator leads (causes) the second one.

We observe the wavelet coherency plot of GPR and NAR in Brazil from 1990 to 2020. In the short run, at a period of scale 0–5 monthly between 1995 and 2015, several arrows are pointing rightward, suggesting a positive relationship between GPR and NAR, with GPR leading NAR. However, in the medium and long run, there is a negative intercorrelation between the two variables during the sample period. Hence, GPR does not promote the natural resources rents in Brazil in the long run. Similarly, the wavelet coherence between GPR and NAR in India has the same findings as in Brazil. The majority of the arrows are leftward in the short and medium run at periods of scale 0-32 monthly from 1995 to 2020, which reveals a negative relationship between GPR and NAR with NAR leading. There is no significant nexus between the two variables in the very long run. These results imply that GPR reduces natural resources rents in India. However, the wavelet coherence between NAR and GPR in South Africa is totally different. At the periods of scale 0-8 monthly, between 1990 and 1995, 2000–2005, and 2015–2020, rightward down and up arrows are observed, which uncovers that GPR has positive associations with NAR and that GPR leads NAR in this country. Furthermore, the arrows are right-down in the long run from 2005 to 2015, suggesting a positive coherence between NAR and GPR.

Finally, in the long term, in the cases of China and Russia, there is a negative nexus between GPR and NAR over the sample period. Nevertheless, in the short term, at a period of 0–8 monthly from 1990 to 1995, some arrows are rightward-up, which suggests an in-phase (positive) relationship between the two indicators with GPR leading. In addition, in the medium term, this scenario is also true during 2015–2020. Overall, geopolitical risks have a negative impact on natural resources rents in the medium and long run in China and Russia, which implies that GPR mitigates NAR in the long run. Table 2 summarizes the wavelet coherence.

Table 2.
Summary of WTC results.

Association	Periods	Correlation significance	Correlation strength	Causality path
India	Short run	$GPR \leftarrow NAR$	Strong	NAR leads GPR
	Medium run	$GPR \leftrightarrow NAR$	Strong	GPR lead NAR
	Long run	$GPR \leftarrow NAR$	No	NAR lead GPR
Brazil	Short run	$GPR \rightarrow NAR$	Strong	GPR lead NAR
	Medium run	$GPR \leftrightarrow NAR$	Strong	GPR lead NAR
	Long run	$GPR \leftrightarrow NAR$	Strong	GPR lead NAR
China	Short run	$GPR \leftarrow NAR$	Strong	NAR lead GPR
	Medium run	$GPR \leftrightarrow NAR$	No	NAR lead GPR
	Long run	$GPR \leftarrow NAR$	No	NAR lead GPR
Russia	Short run	$GPR \leftarrow NAR$	Strong	NAR lead GPR
	Medium run	$GPR \leftrightarrow NAR$	No	NAR lead GPR
	Long run	$GPR \leftarrow NAR$	Strong	NAR lead GPR
South Africa	Short run	$GPR \leftrightarrow NAR$	Strong	GPR lead NAR

	Medium run	$GPR \rightarrow NAR$	Strong	GPR lead NAR
	Long run	$GPR \rightarrow NAR$	No	GPR lead NAR

In general, the WTC results show a strong relationship between geopolitical risks and natural resource rents in the majority of the time and frequency domains in BRICS countries. Even though geopolitical risks positively influence natural resource rents in South Africa at all times and frequencies, they are statistically significant in the rest of the countries only at low and medium frequencies. Nevertheless, the results unveil that the influence of geopolitical risks on natural resources rents is negative and declines as natural resources rents move across medium and low frequencies. This outcome is in line with the previous studies, which confirm a negative influence of GPR on oil rents [8, 13].

Figure 3 reports the lead-lag nexus between GPR and NAR in BRICS economies in time-frequency domains. The graphs in the left column, from top to bottom, refer to the Rua [15] correlations between GPR and NAR. It is clear from the plots that the period of high negative correlation between GRP and NAR is similar to the periods of causal nexus described **in** Figure 2**.** Put another way, there is a strong interplay between GPR and NAR at different time and frequencies, which implies that rises in geopolitical risks predict natural resources rents. This is in line with Ma, et al. [21] and Islam, et al. [7].

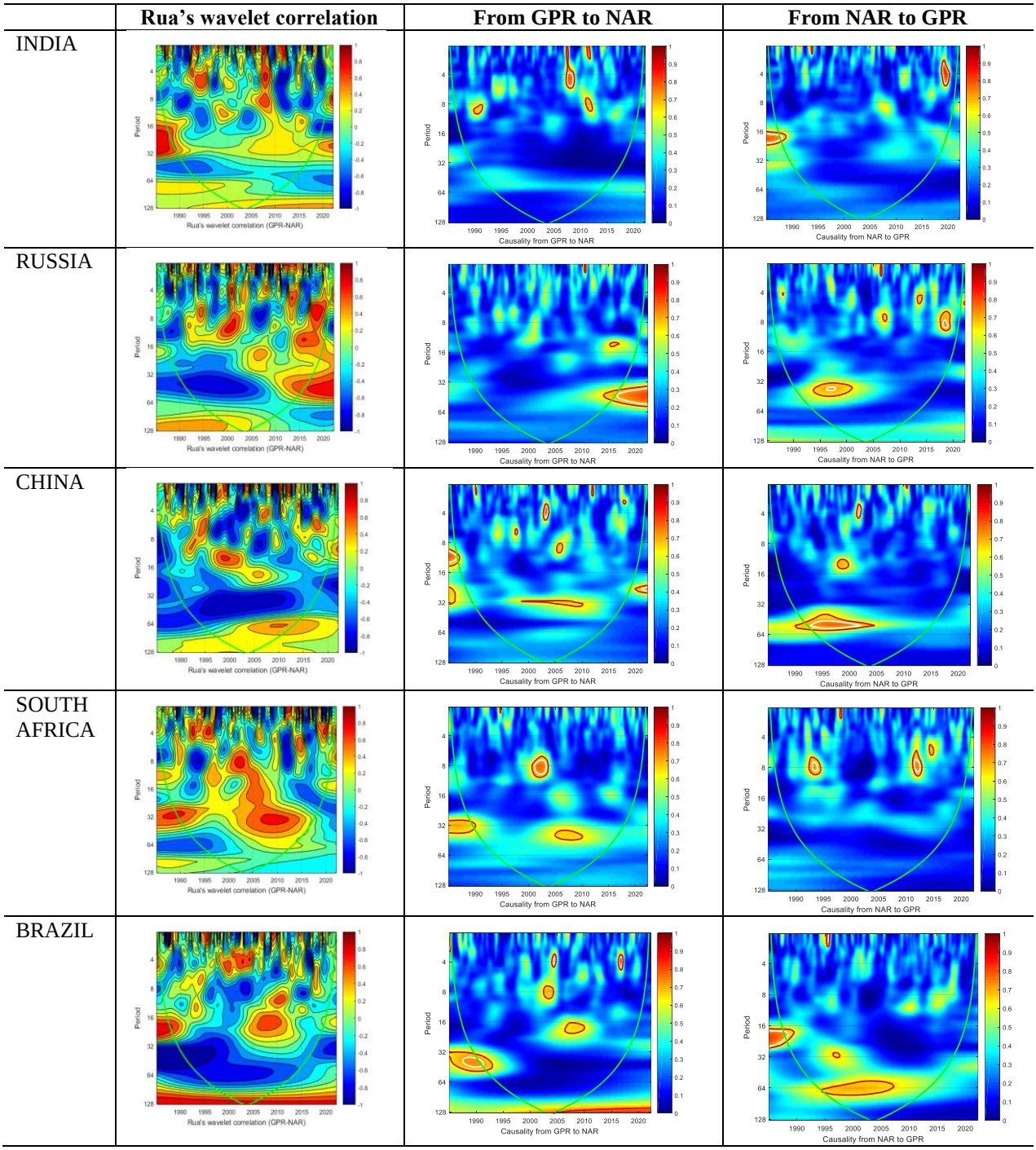


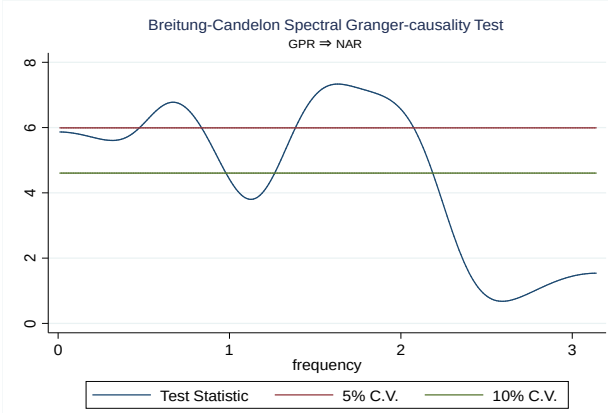
Figure 3.
Time and frequency nexus between GPR and NAR in BRICS countries.

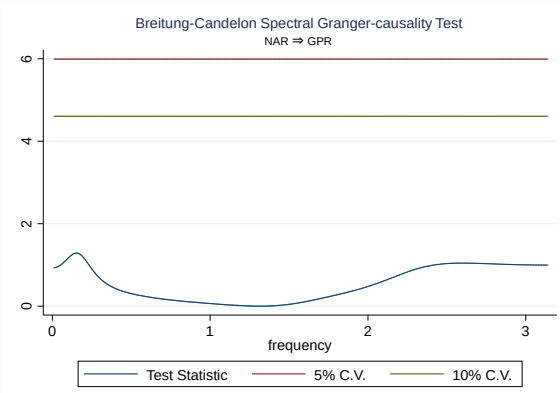
Figure 3 also shows the results of the wavelet-based Granger causality framework of Olayeni [16] between GPR and NAR for BRICS countries. Causal associations are demonstrated through contour plots, and the magnitude of causal interlinks between the two variables is represented by a color code ranging from dark blue (lack of causal effects) to dark red (strong causal effect). The middle column describes the wavelet figures of causal effects from GPR to NAR, while the right-hand side of the figure presents the causal effects from NAR to GPR. These plots disclose that geopolitical uncertainty has a considerable effect on NAR in the short and medium run during the sample period in all countries. On the other hand, the largest proportion of dramatic causal effects running from NAR to GPR is observed at low frequency, suggesting that the lead-lag nexus between these indicators occurs at medium and long-term horizons. These outcomes totally support the findings of wavelet coherence.

4.2. Robustness Check

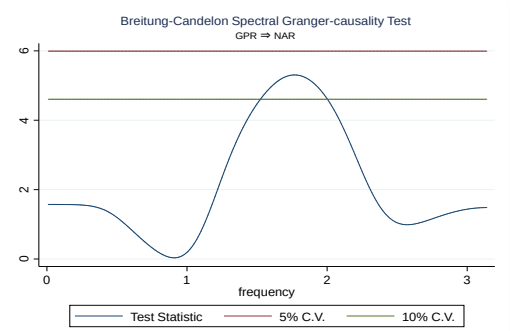
In the robustness analysis, the spectral Granger-causality test of Breitung and Candelon [17] was utilized. We refer the reader to Breitung and Candelon [17] for more information about the model, which enables us to highlight causality tests in the sense of Granger under the frequency domain. Put another way, this approach works well for both stationary and non-stationary time series [36]. The optimal lag for various VAR techniques is chosen based on the Akaike information criterion and the Schwarz Bayesian information criterion. Therefore, the optimal lag is 4. Figure 4 depicts the findings. The spectral causality test's results uncover that in the medium- and long-run, evidence of causality surfaced from GPR to NAR, indicating that the null hypothesis of no causality is rejected at a 10% significance level, which means that GPR can predict NAR in the medium and long term in BRICS countries. In the same vein, in the short and medium run, we found the causality from NAR to GPR at a 10% significance level, revealing that any policies in the short and medium run directed toward the natural resources rents will influence geopolitical uncertainty. Overall, the outcomes reveal that there is a bidirectional causality between geopolitical risks and natural resources rents in BRICS countries. The empirical results of the robustness test largely agree with our primary conclusions and attest to the reliability of the aforementioned analytical findings.

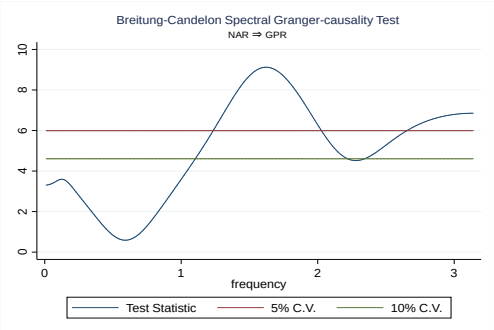
INDIA



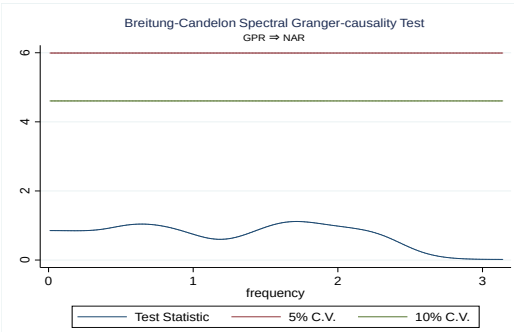


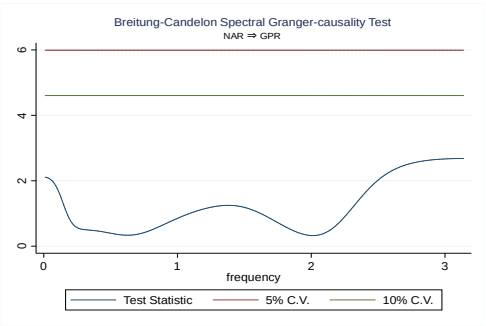
RUSSIA





CHINA





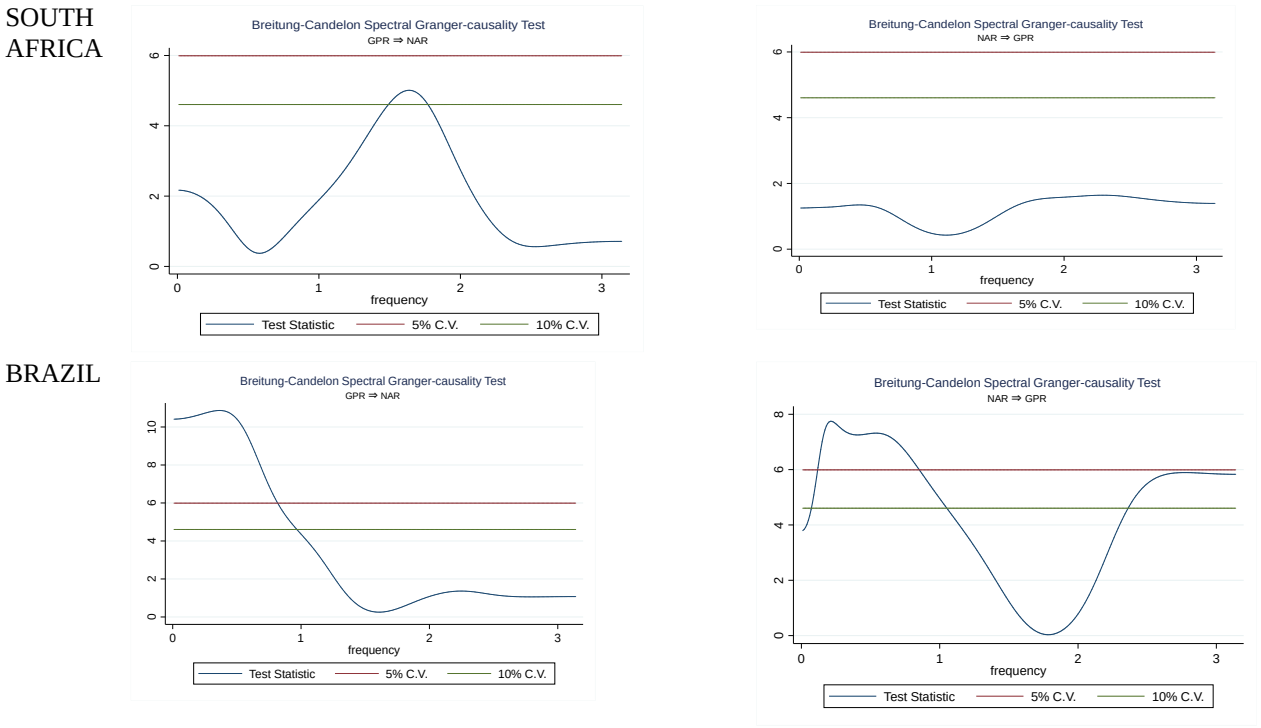


Figure 4.
Breitung-Candelon Spectral Granger Causality Test between GPR and NAR in the frequency domain.

4.3. Discussion

The study findings have illustrated that geopolitical uncertainty negatively affects natural resources rents in China, Brazil, India, and Russia. Expropriation, burden of regulation, violence and public unrest, cultural blunders, and human rights violations would pose a threat to reputation, ownership, financial resources, and the expansion of corruption as geopolitical risks. Furthermore, it would have an influence on our economy and natural resources. The abrupt breaking of some international agreements, the cessation of trade with foreign nations, and the breakup of connections reduce the demand for items made from natural resources, which also lowers the pricing of those products [3]. This outcome is in line with Li, et al. [3] and Sweidan and Elbargathi [12] which uncover that when these countries have geopolitical events such as a regulatory burden, the prices for natural resource products go down. Governments in these nations should enforce stringent regulatory requirements, restrict foreign direct investment, or allow domestic industries to establish monopolies. As a result, the demand for natural resources and products derived from them is disrupted, which lowers product prices. Even though the current analysis establishes the lead-lag relationship between GPR and natural resource rents in BRICS countries while confirming the persistence of the GPR-NAR relationship, this article finds that geopolitical uncertainty has both negative and positive impacts on natural resources rents in BRICS economies in the short and medium run. More importantly, the long-term positive impact of GPR on the NAR in South Africa occurs due to the proper identification of this uncertainty. It assists the South African government in adopting curative measures to exploit natural resources in handling technologies in the renewable energy production system. It is well acknowledged that the share of renewable energy sources may increase as a result of social and political pressures and movements, changing the geopolitical environment [7, 31]. As a result, it implies that geopolitical risks will rise irrespective of either negative or positive innovations in natural resources rents.

In contrast to the results when there is not only a period but also a phase difference in the international economic outlook, there is suggestive evidence that GPR negatively affects NAR during the time window. Reporting the same outcomes, Li, et al. [29] indicate the time and frequency of co-movement and the causal nexus between oil prices and geopolitical risks. Khan, et al. [23] also affirm that oil prices have led to substantial revenues despite the existence of geopolitical uncertainty in the medium run. According to Yang, et al. [24] changes in geopolitical uncertainty in GCC countries can have a significant impact on oil production and prices, and GPR increases, and decreases can influence future economic expectations, which can impact oil production decisions. In addition, China has significant hurdles in ensuring its energy security due to its large reliance on foreign oil and its fossil fuel-based energy system. These challenges include the oil supply and price, both of which are influenced by geopolitical uncertainty.

Overall, our empirical results of wavelet analysis assert a lead-lag relationship between geopolitical risks and natural resources rents in BRICS countries. Geopolitical uncertainty plays a prominent role in identifying oil prices and their direct influence on natural resources. We found a significant intercorrelation in time-frequency domains between GPR and NAR during the sample period. Particularly, during two geopolitical crises (the terrorist attacks of 2001 and the Iraq wars of 2003), both events raised the level of uncertainty and fears about oil supply disruptions [22]. The rising demand from emerging economies also contributes to the rising NAR, which has resulted in significantly higher earnings for oil-exporting nations. Because less oil revenue may be used for development, GPR may be harmful in the long run [31, 32].

4.4. Policy Insights

Based on the empirical results, this paper suggests several practical policy implications which may help encourage economic performance in BRICS countries. One of the main drivers of economic performance is the availability of natural resources Deng, et al. [20] thus it is necessary to enhance policies in connection with natural resources rents. Particularly, natural resources would be used while taking sustainable development or natural resource conservation for future generations into consideration. More importantly, the BRICS governments should take into account natural resource sustainability as a key policy instrument because it will lessen reliance on natural resources. Therefore, our research makes a distinction in the literature because we provide a comprehensive view of the role of geopolitical uncertainty in determining natural resources rents in BRICS economies. Our findings are critical in emerging economies and provide policymakers with guidance on how to control natural resource rents based on the dynamics of geopolitical risks.

Furthermore, we would like to emphasize these results in our article due to their significance for the BRICS economies. The BRICS policymakers should work on two dimensions: Firstly, focus on diversifying the BRICS economies, which will undoubtedly reduce international oil market uncertainty, enhance continuity and productivity of the economy, and increase employment. Secondly, the BRICS institutional system should be promoted. Institutions are unquestionably essential for fostering innovative strength, cutting-edge technology, and maintaining economic growth rates. Also, the impact of institutional quality on economic development is greater than the influence caused by trade or geographical variables. Thirdly, environmental rules must be more severe in the form of renewable energy generation and consumption, which benefits in several ways. Because renewable energy uses reusable materials, the usage of natural resources will decrease. Additionally, the use of renewable energy could be used to replace conventional fossil fuel energy at the industrial or residential level, boosting financial performance and reducing environmental pollution.

5. Conclusion

The most dangerous global concern that economies around the world have had to contend with continues to be geopolitical uncertainty [31, 32]. Natural resources are either a curse or a blessing for a country or region, according to academic discussion. Brazil, South Africa, India, Russia, and China are the five countries with the most natural resources nations. NAR are used as either finished products or raw materials or as raw materials for residential and commercial purposes, with some changes in natural resource characteristics.

The current study utilizes wavelet analysis to examine the connection between geopolitical risks and natural resources rents in BRICS economies in time-frequency domains from 1990 to 2020. We represent methodologies and visualization tools that quantify the time-varying nexus between geopolitical risks and natural resources while exploring key investment-horizon behaviours. Our use of wavelet-based approaches yields solutions for making quantified, fact-driven decisions about the GPR-NAR nexus. The wavelet-based analysis uncovers that the co-movement between natural resources rents and geopolitical uncertainty in BRICS countries appears to be co-varying across divergent time periods and various frequencies.

Using wavelet coherence and the wavelet-based causality techniques proposed by Olayeni [16] a variety of empirical results highlighted that geopolitical risks negatively drive the natural resources rents at medium and low frequencies in China, India, Russia, and Brazil, while GPR has a positive impact on NAR in South Africa during the sample period. In addition, there is a bidirectional association between GPR and NAR at different time and frequency domains in these economies. Our findings are robust to a country-specific investigation using the spectral Granger-causality test of Breitung and Candelon [17]. Natural resources respond to the same degree of geopolitical risk shocks to a greater extent, last longer, and are more affected by them when large geopolitical events occur.

Our study is illuminating and valuable for commodities demand and supply, key policymaking organizations, and futures market investors. Because geopolitical risks have a large impact on commodity price volatility, all parties concerned must closely monitor changes in geopolitical risks and implement effective risk management techniques to limit their impact on commodity price volatility. Natural resources have a long-term impact on output, price stability, and national revenue. Policymakers must classify strategies and change guiding regulations selectively to reduce the impact of extraneous geopolitical risks because different categories of futures respond differently to geopolitical risks. Changes in geopolitical risks have a greater influence on commodities with substantial external dependence, such as copper, crude oil, gold, and iron ore, and their impact lasts longer. Finally, these nations should prioritize joining a global alliance that can reduce any geopolitical uncertainty.

This article suffers from some limitations: macroeconomic variables for limited economies. A future study should aim to conduct a comparative analysis that includes other countries and focuses on the effects of geopolitical risks on renewable energy and environmental degradation in developing economies. In addition, utilizing novel econometric approaches is recommended to implement upcoming studies.

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