Do geopolitical risk and energy consumption contribute to environmental degradation? Evidence from E7 countries

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Abstract
Environmental degradation is frequently cited as one of the eminent issues in the modern era. To limit environmental degradation, prior literature discerns several macroeconomic, socio-economic, and institutional factors that affect environmental degradation. However, the relationship between geopolitical risk and environmental degradation is understudied in the previous literature. To fill this gap, the inquiry at hand aims to scrutinize the influence of geopolitical risk on environmental degradation for E7 countries while controlling the effect of renewable energy, non-renewable energy, and GDP. Further, we utilize both the ecological footprint and CO2 emissions as proxies of environmental degradation and employ second-generation panel methods for robust findings. In addition to this, the present study uses augmented mean group (AMG) estimator to provide long-run relationship among the selected variables. The findings from the AMG estimator expound that there exists environmental Kuznets curve (EKC) for E7 countries. Moreover, renewable energy ameliorates environmental quality because it plunges both ecological footprint and CO2 emissions. On the contrary, non-renewable energy consumption escalates both ecological footprint and CO2 emissions. Finally, geopolitical risk tends to decrease CO2 emissions as well as ecoclogical footprint. Our findings deduce a few policy implications to replenish environmental quality. For instance, the share of renewables in the energy mix should be surged to ameliorate the environmental quality. Further, to control both the geopolitical risk and environmental degradation at the same time, policymakers should put forward reforms and initiatives (e.g., policies to escalate R&D, technological innovations, and tax exemptions on imports of renewables) that can help to improve environmental quality without affecting geopolitical risk. At times of low geopolitical risk, environmental degradation will surge; therefore, the rate of environmental control taxes should be increased by the policymakers.

Keywords Ecological footprint · CO2 emissions · Geopolitical risk · Renewable energy · Non-renewable energy · Augmented mean group estimator

Introduction
The growing number of state and regional instability, energy crisis, terrorist attacks, political copes, and other unfavorable events worldwide has aggravated the issue of geopolitical risk. Geopolitical risk (GPR) is referred to tensions linked with terrorism, wars, and unfriendly relations among countries (Adams et al. 2020) and is important to the economies susceptible to wars or war-like tensions, terrorism, ethnicity, conflict, and political violence. Furthermore, major geopolitical events such as 9/11, London bombing, Madrid bombing, Bombay attacks, China–USA trade war, Korea’s nuclear issues, and Iranian trade tensions all pose a serious threat to the economic stability of a country (Cai and Wu 2020). Geopolitical risk can affect economic performance and investment decisions and trigger business cycles that
impact natural resource rents and financial markets (Price-waterhouseCoopers 2018; Balcilar et al. 2018; Dogan et al. 2021). Unfavorable geopolitical events change the direction of investment spending towards less productive uses like reconstruction and security (Olanipekun and Aloha 2020). Moreover, extreme geopolitical events will cause panic among investors and businesses that will create abnormal fluctuations in the market and eventually influence energy returns and volatility (Qin et al. 2020). Subsequently, GPR is considered as one of the top five business threats globally (Price Waterhouse Coopers 2018). Recently, Syed et al. (2021) highlight that geopolitical risk also exerts detrimental impacts on tourism.

Geopolitical events have harmful consequences not only on social and economic life but also on the environment. Anser et al. (2021a) put forward two theoretical channels that link GPR and the environment. The first channel is called the “escalating effect” which describes that GPR mitigates renewable energy consumption (hereafter REC) which in turn leads to higher carbon emissions. Parallel to this, the “mitigating effect” expounds that GPR curtails non-renewable energy consumption (hereafter NREC) and economic growth leading to a reduction in CO₂ emissions. In another study, Anser et al. (2021b) pointed out that GPR affects economic growth, R&D investment, innovations, technological advancements, and investment in clean energy. These aforementioned indicators eventually escalate emissions. Therefore, GPR may either curb or surge carbon emissions.

Based on the above milieu, this research contributes to the existing empirical literature by exploring the impact of GPR, economic growth, NREC, and REC on environmental degradation. To attain this, firstly, we use the recently introduced GPR index developed by Caldara and Iacoviello (2018). Despite the significance of the prior studies and their results, the proxies of geopolitical events (e.g., terrorism/terrorist attacks, war or militarization, and political instability) have some limitations of not in real-time, being discontinuous, and not covering the real geopolitical events. Moreover, these proxies do not accurately describe GPR as they do not account for all events, ranging from economic crisis to wars to climate change (Bouoiyour et al. 2019). The GPR index captures the risk associated with terrorist attacks, military threats, war risk, political tensions, and geopolitical uncertainty. This index is superior to other indicators as it offers a time-consistent, holistic, and real-time approach to capture GPR. Moreover, the GPR index integrates both present and expected future risks (Muhammad and Long 2021).

Secondly, many countries aim to achieve the goal of energy security for the smooth functioning of their economies and easy access of their people to modern and clean energy supplies (Ayoo 2020). Economic, social, and human well-being depends on the production of goods which further depend on the availability of energy (Bompad et al. 2017). It is a well-established fact that economic growth and well-being are closely correlated (Warr and Ayers 2010). A plethora of energy challenges including high energy prices, uncertain energy supplies, environmental degradation, and inadequate supplies of energy sources are being faced by both developed and developing economies. Countries with high reliance on energy imports are vulnerable to risks and threats associated with energy supplies (Yergin 2006). E7 countries, with their ever-increasing energy demand due to population growth and robust economic expansion, heavily depend on energy imports to reduce poverty and to uplift the well-being of their people. Therefore, economic security which is strongly correlated with energy security remains a challenge for E7 countries.

Thirdly, the study focuses on E7 countries (Brazil, China, Indonesia, India, Mexico, Turkey, and Russia), which according to Earth System Science Data (ESSD) (2020) emit approximately 45% of global CO₂ emissions. Four of the world’s highest CO₂ emitter countries (China, India, Russia, and Indonesia) are part of this group. A high level of growth and the consequent high energy consumption in these economies cause a substantial increase in CO₂ emissions. Moreover, these countries are strong political powers, and they have political tensions as well. According to Global Risks Report (2021), E7 countries are among the most critical countries based on their socio-economic and geopolitical conditions. For instance, being the second largest economy and most populated country in the world, China has been an important political economy that might affect the whole world. Moreover, the China–USA trade war has been one of the prime reasons behind the geopolitical tensions between these countries that have led to global tensions worldwide. Further, border tensions between China and India exert pressure on both countries which in turn affect the social and economic life of consumers and producers of both countries. Brazil has disputes with Uruguay and Colombia on smuggling and immigration. Moreover, unstable governments and impeachments contribute to geopolitical instability in the case of Brazil. As mentioned earlier, India has a long history of border tensions with its neighbors such as China and Pakistan. Also, the world has witnessed several wars between India and its neighbors which have created spikes in geopolitical tensions. Further, following the USA and UK, India is the third country with the highest number of cyber-attacks in the last two decades. Likewise, Mexico, Turkey, and Russia have been facing several issues with the USA and a few other countries. E7 economies have border tensions with their neighbors, and they also have (geo)political instability that contributes to economic uncertainty. It is worth mentioning that, according to the Global Risks Report (2021), COVID-19 has been exerting a detrimental impact on the economies of E7 countries which have experienced even negative economic growth during the COVID-19 pandemic.
Moreover, due to lockdowns and other stringency measures, the energy sector has also witnessed a negative supply shock that has led to the high vulnerability of the energy sector.

Fourthly, we employ a comprehensive measure of environmental degradation, i.e., ecological footprint (hereafter EF) along with CO₂ emissions to have more robust and insightful conclusions. Fifthly, we have disaggregated energy consumption by source, NREC, and REC, to see their separate role in escalating environmental degradation in anticipation of GPR. Finally, to overcome the problem of heterogeneity and cross-sectional dependency, the present study uses the second generation of panel data methods. In addition to this, we also employ CIPS unit root tests, Westerlund cointegration test, and augmented mean group (AMG) estimator to render robust and consistent estimates in the existence of cross-sectional dependence and heterogeneity (Baloch and Wang 2019).

Literature review

Environmental pollution has been the core of empirical as well as theoretical discussion for many years until now. (Dahish and Recep 2020).

Based on the GPR index presented by Caldara and Iacoviello (2018), the role of GPR on energy consumption and environmental degradation has been explored by a few studies in recent years. In the case of Russia, Rasoulinezhad et al. (2020) tested the relationship between energy transition and GPR from 1993 to 2018. They detected a positive influence of GPR, CO₂ emissions, financial openness, and exchange rate on energy transition, whereas the economic growth, inflation rate, and population growth negatively affect the energy transition. Moreover, the relationship between economic growth, energy transition, CO₂ emissions, inflation rate, and population growth is negative in the short run. On the contrary, financial openness, GPR, and exchange rate accelerate the energy transition. Their results further revealed that in the short run, GPR is the main contributor to the energy transition. Recently, Alsagr and Hemmen (2021) explored the dynamic impact of GPR and financial development on REC during 1996–2015 in 19 emerging economies. The results of GMM revealed a positively significant influence of financial development on energy consumption. Similarly, in the case of the USA, Sweidan (2021) concluded that GPR has a statistically significant and positive effect on energy diffusion. It implies that GPR drives energy rather than depressing it.

Adams et al. (2020) investigated the relationship between economic policy uncertainty and NREC for 10 resource-rich economies with a high level of GPR from 1996 to 2017 in the long run. The findings of Kao’s test reveal a cointegration association among GPR, NREC, economic policy uncertainty, economic growth, and CO₂ emissions. Moreover, the PMG-ARDL results show that uncertainty, economic growth, and NREC contribute to CO₂ emissions. This indicates that economic policy uncertainty has a detrimental impact on the environment. They found a significant relationship between uncertainty and emissions in the long run. Lastly, the results of the DH causality test show a one-way causal relationship running from CO₂ emissions to GPR and a two-way causal relationship among CO₂ emissions and NREC, economic growth and CO₂ emissions, and economic policy uncertainty and CO₂ emissions.

Likewise, Anser et al. (2021a) probe the effect of GPR on the EF in the case of BRMCC (Brazil, Russia, Mexico, China, Colombia) using AMG estimators. The study concludes that GPR mitigates environmental degradation. Zhao et al. (2021) examined the asymmetric impact of GPR on carbon emissions in the case of BRICS countries using the NARDL approach. The findings from the study reveal that the impact of GPR on carbon emissions is asymmetric, and it is heterogeneous across the BRICS countries. Anser et al. (2021b) estimated the impact of GPR, REC, NREC, economic growth, population, and economic growth on CO₂ emissions in BRICS countries. They employed the second-generation analysis and AMG estimator. The results indicate that GPR, GDP, population, and NREC escalate CO₂ emissions and REC reduces emissions in BRICS. It is worth mentioning that prior studies on the GPR–environment nexus either use CO₂ emissions or EF as a proxy for environmental degradation. Next, no study expounds on the renewable energy–environment and non-renewable energy–environment nexus amidst GPR. However, we employ both CO₂ emissions and EF as a proxy for the environment. Recently, Hashmi et al. (2021) use global emissions and GPR to explore the worldwide nexus between GPR and emissions. They note that GPR is a key determinants of global carbon emissions.

It is important to know that risk due to the COVID-19 pandemic has also affected both energy and the environment. For instance, Iqbal et al. (2021) revealed that the COVID-19 outbreak mitigates both NREC and carbon emissions. In the case of India, Aruga et al. (2020) conclude that lockdown amid the COVID-19 outbreak plunges NREC. Algamdi et al. (2021) find that the COVID-19 outbreak impedes both NREC and carbon emissions. In addition, Wang and Su (2020) reported that the COVID-19 outbreak decreases NREC and hence improved the environmental quality in China. In the case of India, Lokhandwala and Gautam (2020) conclude that the COVID-19 outbreak improved both air and water quality. So, it could be perceived that the risk associated with COVID-19 has a positive effect on energy security and environmental quality (Table 1).
| Study | Country | Time frame | Methodology | Variables, (geopolitical risk proxies) used | Conclusion |
|-------|---------|------------|-------------|--------------------------------------------|-------------|
| Zhao et al. (2021) | BRICS | 1985–2019 | Non-linear autoregressive distributed lag (NARDL) | CO2 emissions, NREC, GDP per capita, GPR index, and government stability index | GPR reduces CO2 emissions in South Africa and NREC in India in the short run. In the long run, GPR reduced NREC in South Africa, India, and Brazil and CO2 emissions in South Africa |
| Adams et al. (2020) | 10 resource-rich countries (China, Brazil, Saudi Arabia, India, Turkey, Russia, South Africa, Ukraine, Israel, and Venezuela) | 1996–2017 | PMG-ARDL | CO2 emissions, real GDP, NREC, GPR, economic policy uncertainty | CO2 emission → GPR, CO2 emission ↔ NREC, CO2 emission ↔ economic policy uncertainty |
| Rasoulinezhad et al. (2020) | Russia | 1993–2018 | ARDL method | CO2 emissions, GPR, economic growth, population growth, energy transition, financial openness, exchange rate | The negative impact of population, inflation, and economic growth on energy transition found. The positive impact of GPR, CO2 emissions, financial openness, and exchange rate on energy transition was detected |
| Anser et al. (2021b) | BRICS | 1995–2015 | Augmented mean group | GPR, per capita GDP, NREC, REC, population growth, CO2 emissions | GPR, population, and NREC escalate CO2 emissions. REC impedes CO2 emissions |
| Bildirici (2020) | China, India, Israel, and Turkey | 1975–2017 | Pedroni cointegration test, DH causality test | Terrorism (GPR proxy), NREC, economic growth, FDI inflow, and CO2 emissions | Terrorism → FDI, energy use → CO2 emissions, GDP ↔ CO2 emissions, GDP ↔ FDI, energy use ↔ CO2 emissions |
| (Bildirici and Gokmenoglu, 2020) | Afghanistan, Philippines, Iraq, Pakistan, Nigeria, Syria, Thailand, Somalia, and Yemen | 1975–2017 | Panel cointegration test, ANOVA test, panel trivariate test | CO2 emissions, terrorism (GPR proxy), FDI, NREC, GDP | FDI → CO2 emissions, terrorism ↔ CO2 emissions, FDI ↔ CO2 emissions |
| Sarkodie and Adams (2018) | South Africa | 1971–2017 | Structural break cumulative sum (CUSUM), OLS, ARDL | Political institutional quality (GPR proxy), NREC, GDP, urban population, REC, fossil fuel energy, nuclear electricity net generation | Political and institutional stability mitigate emissions |
| (Bildirici (2017a) | G7 countries | 1985–2015 | Panel ARDL, panel trivariate causality test | NREC, defense expenditure (a measure of militarization and proxy of GPR), CO2 emissions, per capita GDP | Militarization → CO2 emissions, NREC ↔ CO2 emissions, NREC ↔ militarization, GDP ↔ militarization, GDP ↔ NREC |
| Bildirici (2017b) | USA | 1960–2013 | MWALD, Rao’s F test | Militarization (GPR proxy), CO2 emissions, NREC, GDP | Militarization → CO2 emissions, NREC → CO2 emissions, militarization → NREC |
| Bildirici (2017c) | USA | 1984–2015 | ARDL, dynamic OLS, FMOLS, cointegration regression, MWALD, and Rao’s F test | Defense expenditure (a measure of militarization and GPR proxy), biofuel consumption, CO2 emissions, per capita GDP | Militarization ↔ biofuel consumption, CO2 emissions ↔ biofuel consumption, biofuel consumption ↔ GDP |
Model and methods

In the literature of environmental economics, several empirical models have been developed to link the environment with the economy. It is worth noting that the EKC hypothesis has been regarded as the most critical theory of environmental economics that has been extensively tested in empirical studies. The EKC is an inverted U-shaped relationship between environment and income, and, in this analysis, we extend the EKC framework by including GPR and energy consumption:

\[ CO_2 = f(GDP, GDP^2, NREC, REC, GPRI) \]  

\[ EF = f(GDP, GDP^2, NREC, REC, GPRI) \]

In Eqs. (1) and (2), GDP and GDP\(^2\) denote real GDP per capita and square of real GDP per capita, respectively. NREC and REC represent non-renewable energy consumption and renewable energy consumption, respectively. Further, GPRI is the geopolitical risk index. CO\(_2\) is carbon dioxide emissions, whereas EF is the ecological footprint. These aforementioned variables (CO\(_2\) and EF) are employed as an environmental degradation proxy. It is hypothesized that the magnitude of the coefficient of GDP and GDP\(^2\) is > 0 and < 0, respectively. This means that EKC does exist, implying that, at the initial stages of economic growth, environmental degradation also increases and decreases as economic growth exceeds a certain point. Several recent studies use the EKC framework to explore the determinants of environmental degradation (see, for example, Destek and Sarkodie 2019; Syed and Bouri 2021; Haider et al. 2020). In addition to this, we further hypothesized that the coefficient of NREC and REC is > 0 and < 0, respectively. This indicates that non-renewable energy escalates environmental degradation, while renewable energy impedes it (see, for example, Anser et al. 2021c; Bhowmik et al. 2021; Ali et al. 2020; Gardiner and Hajek 2020). Next, it is hypothesized that the coefficient of GPRI is < 0, depicting that GPR plunges the environmental degradation (see, for example, Adams et al. 2020). It is stated that this outcome is possible if the mitigating effect exceeds escalating effect.

The present study utilizes an annual panel dataset for E7 economies (Brazil, China, India, Indonesia, Mexico, Russia, and Turkey) over the period 1990–2015. The dependent variables are CO\(_2\) emissions (measured in metric tons per capita) and ecological footprint (measured in Gha per person). On the other hand, independent variables are real GDP per capita (GDP), NREC, REC, and GPR index (GPRI). GPRI is established by Caldara and Iacoviello (2018), which is calculated based on the frequency of the newspaper articles containing the words, for example, “geopolitics,” “geopolitical risk,” and “geopolitical
tension. The summary of data is given in Table 10 in the Appendix. In addition, we employ several cross-sectional dependence tests, second-generation unit root tests, second-generation cointegration tests, and augmented mean group (AMG) estimator for robust analysis.

Table 2 exhibits the descriptive statistics of study variables. The mean value of GDP is the highest, whereas it is the lowest for CO2 emissions. Also, the standard deviation is the highest for EF, while it is the minimum for GPRI. Moreover, GPRI is positively skewed, while all other variables are negatively skewed. In addition to this, Jarque–Bera test statistics highlight that the selected dataset follows the non-normal distribution.

All variables are transformed into logarithmic form. (.) indicates $t$ statistics, whereas [.] shows $P$ values. *, **, and *** represent 10%, 5%, and 1% levels of significance, respectively.

Results and discussion

Results

To achieve its objective (i.e., probing the impact of GPR, NRE, and REN on the environment), in this section, the current study reports the results from second-generation panel data methods and AMG estimators coupled with the panel causality test. First, we report the results of the Breusch–Pagan LM test, the Pesaran LM test, and the Pesaran CD test in Table 3.

The null hypothesis of the Westerlund test indicates that there is no cointegration among the variables. In addition, ***, **, and * report 1%, 5%, and 10% levels of significance, respectively.

The null hypothesis of all CD tests describes that there is no cross-sectional dependence (CD). The findings from CD tests reveal that at 1% level of significant, null hypothesis could be rejected, indicating that there exists CD in our case. This implies that shocks in one country can transmit to another country. Next, we test unit root in all selected variables to identify the order of integration. The results from the CIPS unit root test of Pesaran (2007) are given in Table 4.

We fail to reject the null hypothesis of “there is no unit root at I (0).” However, at a 1% level of significance, we could reject the null hypothesis at I (1). This specifies that...
all selected variables are integrated of order 1. In Table 5, the results of the Westerlund (2007) test of cointegration are shown. The test consists of four different test statistics, and the null hypothesis of all these statistics postulates that cointegration does not exist.

We employ ecological footprint (EF) and carbon dioxide emissions (CO2) as a proxy for environmental degradation, hence applying Westerlund (2007) test two times. We do not fail to reject the null hypothesis, which indicates that there is no cointegration among the selected variables. Hence, we can conclude that there is an existence of cointegration among the selected variables used in the model.

Further, Westerlund (2007) test does not render long-run estimates (elastocities); therefore, we apply the AMG estimator to avail long-run estimates. The findings of the AMG estimator using CO2 emissions as environmental degradations’ proxy are reported in Table 6.

In Table 6, all reported variables are statistically significant. Further, the sign of GDP and GDP^2 is positive and negative, respectively. Therefore, we note the validity of EKC for E7 countries. This outcome is in line with the conclusion of Anser et al. (2021b). Next, the value of NREC is 0.17, indicating that a 0.17% upsurge in carbon emissions is fostered by a 1% raise in NREC. Therefore, we conclude that NREC escalates emissions. This finding conforms with the results reached by Gardiner and Hajek (2020). Additionally, the value of REC is −0.09, implying that a 1% rise in REC plunes CO2 emissions by 0.09%. This means that REC reduces CO2 emissions in E7 countries (Alola et al. 2019). The coefficient of GPRI is −0.08, indicating that a 0.08% decrease in CO2 emissions is fostered by a 1% surge in GPRI. There are a few possible reasons behind the negative impact of GPRI on CO2 emissions. First, high GPRI may discourage consumption and production, which sequentially impedes CO2 emissions. Second, GPRI could affect energy prices, international trade, and tourism activities. These factors may constraint CO2 emissions. Our findings are also backed by the study of Adams et al. (2020) and Anser et al. (2021a) who noted that GPRI impedes environmental degradation. However, our findings are inconsistent with the conclusion of Anser et al. (2021b) who reported that GPRI leads to higher carbon emissions.

Likewise, we use EF as a proxy for environmental degradation and scrutinize the impact of REC, NREC, and GPRI employing an AMG estimator. The estimates are reported in Table 7.

Table 7 depicts that all coefficients are statistically significant. Next, the GDP and GDP^2 coefficients are positive and negative, respectively. Thus, we validate the presence of EKC which is an inverse U-shaped relationship between income and environment. This outcome is supported by the conclusion of Destek et al. (2018). Additionally, the value of NREC is 0.13, explaining that a 1% rise in NREC surges EF by 0.13%. This conclusion is in line with the conclusion reached by Destek and Sinha (2020). On the contrary, the coefficient of REC is −0.02 implying that a 0.02% decrease in EF is fostered by a 1% increase in REC. Additionally, the value of GPRI is −0.10 inferring that a 1% upsurge in GPRI impedes EF by 0.10%. As mentioned earlier, a decrease in production and consumption activities due to high GPRI could be the possible reason behind low levels of EF. This result is supported by Adams et al. (2020) who argue that GPRI plunges environmental degradation.

Finally, we employ the DH causality test to examine the direction of causality. The findings of the DH test are reported in Tables 8–9.

As can be seen from Table 8, there exists one-way causality running from GDP to carbon emissions. Next, one-way causality is also running from GPRI to CO2 emissions. Likewise, one-way causality is running from CO2 emissions to NREC, from GDP to NREC, from REC to GDP, from REC to GPRI, and from NREC energy to REC.

According to Table 9, there exists unidirectional causality running from NREC to GDP, from REC to GDP, from NREC to GPRI, from GPRI to EF, from NREC to EF, and

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**Table 6** Long-run estimates from AMG estimator

| Variable | Coefficient | St. error | Z stat | P value |
|----------|-------------|-----------|--------|---------|
| GDP      | 0.211       | 0.220     | 2.669  | (0.003)*** |
| GDP^2    | −0.060      | 0.122     | −3.213 | (0.002)*** |
| NREC     | 0.171       | 0.330     | 2.851  | (0.003)*** |
| REC      | −0.094      | 0.121     | −3.202 | (0.002)*** |
| GPRI     | −0.082      | 0.212     | −2.694 | (0.002)*** |
| Constant | 0.011       | 0.121     | 0.091  | (0.921)  |
| RMSE (sigma) | 0.0171 | |
| Wald test | (0.001)*** | |

*** represents the level of significance at 1%. (.) denotes P value.

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**Table 7** Results from AMG estimator

| Variable | Coefficient | St. error | Z stat | P value |
|----------|-------------|-----------|--------|---------|
| GDP      | 0.171       | 0.243     | 4.581  | (0.001)*** |
| GDP^2    | −0.050      | 0.136     | −3.553 | (0.002)*** |
| NREC     | 0.131       | 0.221     | 4.512  | (0.001)*** |
| REC      | −0.024      | 0.143     | −3.612 | (0.002)*** |
| GPRI     | −0.107      | 0.127     | −3.001 | (0.002)*** |
| Constant | −0.11       | 7.501     | 0.852  | (0.394)  |
| RMSE (sigma) | 0.0271 | |
| Wald test | (0.002)*** | |

*** represents the level of significance at 1%
that a 1% rise in NREC fostered the emissions by 17%. In the empirical literature, there is a predictable consent on the adverse environmental effect of NREC based on fossil fuel. Some respective studies including Gorus and Aydin (2019) for MENA countries; Nathaniel and Khan (2020), Tuna and Tuna (2019), and Hanif et al. (2019) for ASEAN countries; Sinha et al. (2017) and Sinha et al. (2019) for N-11 economies; Sharif et al. (2019) for 74 nations; Zhang et al. (2019) for 35 developed and developing countries; and Sharma et al. (2021) for eight developing economies of Asia.

The Westerlund (2007) cointegration test illustrates that all variables in the current study are cointegrated (which proposes that there is an effective long-term connection among EF, CO2, GDP, NREC, REC, GPRI in E7 countries). The findings are in line with the results of Sharma et al. (2021) for eight developing countries of Asia, Sharif et al. (2019) for 74 nations, Le and Bao (2020) for 16 developing economies, Shafei and Salim (2014) for OECD economies, and Zafar et al. (2019) for emerging economies. The long-run estimates from AMG show that NREC significantly promotes environmental degradation in E7 countries. The use of NREC exerts pressure on natural resources exploitations, and NREC emits higher carbon gas. As a result, environmental degradation occurs at a higher pace. The use of NREC still dominates in E7 countries; therefore, environmental degradation has been increasing over time. The results expound that a 1% raise in NREC fostered the emissions by 17%. In the empirical literature, there is a predictable consent on the adverse environmental effect of NREC based on fossil fuel. Some respective studies including Gorus and Aydin (2019) for MENA countries; Nathaniel and Khan (2020), Tuna and Tuna (2019), and Hanif et al. (2019) for ASEAN countries; Sinha et al. (2017) and Sinha et al. (2019) for N-11 economies; Sharif et al. (2019) for 74 nations; Zhang et al. (2019) for 35 developed and developing countries; and Sharma et al. (2021) for eight developing economies of Asia.

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Furthermore, the results also indicate that a 1% hike in GPRI tends to reduce CO2 emissions by 9%. Renewables in the form of wind energy, hydropower energy, and solar energy, etc. do not emit greenhouse gases (e.g., CO2). Further, renewables do not exploit and deplete the natural resources and hence environmental degradation plagues. Since E7 countries are among the top countries that are shifting from NREC to REC, hence, they are at the right part by escalating the REC to achieve sustainable development. These findings are parallel with the conclusions attained by Al-Mulali and Ozturk (2015) for 23 selected European countries, Nathaniel and Khan (2020) for ASEAN countries, Sharif et al. (2019) for 74 nations, and Dogan and Aslan (2017) for EU countries. In contrast, our findings are inconsistent with the conclusions of Mehdi and Slim (2017) who report findings opposite to our conclusion for North African countries.

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investment decisions and can alter financial and economic businesses because countries with secure political and social conditions witness a high level of investment. The change in investment decisions (due to GPRI) could be the reason behind the decline in the levels of CO$_2$ emissions. It is worth reporting that the mitigating effect dominates the escalating effect in E7 countries, depicting that the net impact of GPRI on the environment is negative. Although E7 countries have become the hub of GPRI nowadays and they are being economically affected by GPRI, GPRI does not affect the environmental degradation in these countries. Our findings are compatible with Akadiri et al. (2020) Turkey, Kannadhasan and Das (2020) Asian emerging stock market, Balcilar et al. (2018) BRICS countries, Al Mamun et al. (2020) USA, Das et al. (2019) Asian emerging stock market, and Cheng and Chiu (2018) for 38 emerging countries.

AMG estimator indicates that a 1% rise in NREC will escalate EF by 13%, whereas a 1% rise in REC will lessen the EF by 2%. This argument is compatible with the conclusions reached by Destek and Sinha (2020) in the case of 24 OECD nations and Sharif et al. (2020) for Turkey. The impact of REC is significant and negative on the EF. This describes the clean role of REC in depleting the EF. The findings also expound that E7 economies are on the right track towards achieving the goal of development through the incorporation and progression of environmentally friendly advances. This is equivalent to the conclusion of Danish et al. (2020) for BRICS economies, Destek and Sinha (2020) for 24 OECD nations, Wang and Dong (2019) for 14 SSA countries, and Destek et al. (2018) for EU economies. A 1% rise in GPRI hinders EF by 10%. As mentioned above, it is because of a decrease in production and consumption activities due to high GPRI. Also, GPRI creates uncertainty, which drives firms to put their tentative plans on hold and decrease current production to their limited capacity in anticipation to lower consumption. As GPRI has become the main indicator in economic and business cycles, significant players of economic activities including bankers, industrialists, and market traders accept that GPRI changes the element of the capital market and impedes the dynamics of investment (Caldara and Iacoviello 2018). Moreover, due to the negative and positive signs of GDP and GDP$^2$, the current study validates the EKC for E7 countries. The other studies that confirm the existence of EKC include Al-Mulali and Ozturk (2016) for 27 advanced economies, Bilgili et al. (2016) for OECD nations, and Bölük and Mert (2015) for Turkey. In contrast, Al-Mulali and Ozturk (2015) in the case of 23 European economies do not support the presence of EKC.

The findings from the DH causality test highlight that there exists one-way causality running from GPRI to EF and from GPRI to CO$_2$ emissions. This implies that GPRI affects environmental degradation, but environmental degradation does not affect GPRI in the selected countries. That is, environmental degradation is not one of the reasons behind geopolitical tensions, but GPRI alters environmental degradation. Next, there exists one-way causality running from NREC to economic growth, indicating that non-renewables contribute to economic growth. However, economic growth does not affect NREC. Thus, the current study validates the growth hypothesis. Likewise, regarding the nexus between REC and economic growth, we also find the existence of a growth hypothesis. Hence, it could be concluded that E7 countries depend on energy consumption, and any action to conserve energy will affect economic growth.

**Conclusion**

The threat due to global warming and environmental degradation calls for investigating the socio-economic factors that drive these critical issues (i.e., global warming and environmental degradation). In the prior literature, economic growth and NREC have widely been probed as drivers of environmental degradation; however, there is a dearth of literature on the geopolitical risk–environment nexus. In addition, the limited literature on geopolitical risk–environment nexus has a contrasting conclusion that calls for further exploration of this line of research. Hence, this study probes the impact of GPRI on environmental degradation, controlling the effects of economic growth, NREC, and REC in the case of E7 countries. This study contributes to the existing literature by using carbon emissions and EF as proxies for the environment in the case of E7 countries that provide robust findings. In addition, this study employs several second-generation panel data methods, AMG estimators, and DH causality tests for robust and reliable findings.

The empirical evidence shows that the data set has cross-sectional dependence revealing spillover effects of macroeconomic shocks occurring in any of the countries. All variables are cointegrated which suggests that there exists an effective long-term connection among all the considered variables in the case of E7 countries. The long-run empirical estimates from AMG estimator show that there is a significant impact of NREC on environmental degradation; however, REC contributes to environmental improvements. This provides a solid argument that escalating REC helps decrease CO$_2$ emissions. Secondly, results also depict that if GPRI increases, it will reduce CO$_2$ emissions. On the contrary, using EF as a proxy for environmental degradation, we report that NREC escalates EF and REC lessens the EF. Furthermore, results also depict that rise in GPRI will tend to impede EF. The present study also confirms the presence of EKC for E7 countries. Findings from the causality test imply that GPRI affects environmental degradation, but environmental degradation does not lead to geopolitical risk.
Moreover, we report the validity of the growth hypothesis (in the case of both renewable and non-renewable energy consumption) which is one-way causality running from NREC to economic growth. The results suggest that to guarantee sustainable growth, E7 countries should invest in clean energies since global warming is becoming a more serious problem worldwide. Next, investment in REC is more proficient to limit CO₂ emissions. Different sectors must be urged to adopt innovation that limits contaminations, and it will also help them to lessen their dependency on energy as well as to stimulate the energy security of countries that import energy. Furthermore, governments should provide subsidies on the import of renewable energy productions, as they ameliorate the environmental quality. There should be special research grants for renewable energy development. On the contrary, the government should impose high trade barriers on the import of non-renewable energy. Also, programs and schemes should be initiated to make people aware of the adverse effects of non-renewable energy use. Moreover, E7 countries are on the right track, as the findings from the EKC hypothesis suggest that high real income (above a threshold) leads to improved environmental quality. Furthermore, policymakers should keep in mind the environmental impacts of reducing GPR. In addition to this, if policymakers aim to reduce GPR and environmental degradation simultaneously, they should explore the other factors (e.g., renewables) that impede environmental degradation without affecting GPR. Moreover, policymakers should devise policies to encourage R&D investment, technological advancement, and green energy investment because these factors might curb environmental degradation without causing a surge in GPR. Additionally, at the time of low GPR, government officials and/or policymakers should divert their attention towards environmental degradation because low GPR leads to higher energy consumption and economic growth, which in turn deteriorate the environment. Apart from this, keeping in view the inverse relationship between GPR and the environment, higher environmental taxes should be imposed at times of high GPR and vice versa.

Regarding the limitations of this study, we analyze the emerging countries; so, this study does not propose any policy suggestions for developed countries. Next, the present study does not explain the country-wise findings on the relationship between GPRI and the environment. Regarding future research directions, researchers can explore the nexus between GPR and the environment in the case of developed countries. In terms of methodology, the non-linear or asymmetric impact of GPR on the environment could be examined. The direct and indirect impact of GPR on the environment can also be probed. Furthermore, structured machine learning panel data regression models can be used for future prediction to test the hypothesis related to GPR, carbon emissions, and environmental degradation.

### Appendix

#### Table 10

| Null hypothesis | Obs | F statistic | Prob |
|-----------------|-----|-------------|------|
| GPRI = > GDP    | 150 | 0.75714     | 0.3856 |
| GDP = > GPRI    | 0.11763 | 0.7321     |      |
| NREC = > GDP    | 150 | 13.8135     | 0.0003*** |
| GDP = > NREC    | 0.73266 | 0.3934     |      |
| REC = > GDP     | 150 | 10.6580     | 0.0014*** |
| GDP = > REC     | 1.24775 | 0.2658     |      |
| EF = > GDP      | 150 | 13.3061     | 0.0004*** |
| GDP = > EF      | 38.2782 | 6.E-09*** |      |
| NREC = > GPRI   | 150 | 4.18941     | 0.0425** |
| GPRI = > NREC   | 1.28351 | 0.2591     |      |
| REC = > GPRI    | 150 | 4.99227     | 0.0270** |
| GPRI = > REC    | 3.14574 | 0.0782* |      |
| EF = > GPRI     | 150 | 0.00237     | 0.9613 |
| GPRI = > EF     | 25.6840 | 1.E-06*** |      |
| REC = > NREC    | 150 | 4.37775     | 0.0381** |
| NREC = > REC    | 5.01726 | 0.0266** |      |
| EF = > NREC     | 150 | 0.49467     | 0.8240 |
| NREC = > EF     | 28.1238 | 4.E-07*** |      |
| EF = > REC      | 150 | 1.51391     | 0.2205 |
| REC = > EF      | 33.3736 | 4.E-08*** |      |

Environmental Science and Pollution Research (2022) 29:41640–41652
Table 10 Variables with their measures and sources

| Abbreviation | Indicator name                  | Measurement scale          | Source                        |
|--------------|---------------------------------|-----------------------------|-------------------------------|
| EF           | Ecological footprint            | Gha per person              | GFN, Global Footprint Network |
| CO<sub>2</sub> | CO<sub>2</sub> emissions        | Metric ton per capita       | WDI, World Development Indicators |
| GDP          | GDP per capita                  | Constant 2010 SUS           | WDI                           |
| NREC         | Non-renewable energy consumption| Oil equivalent per capita   | WDI                           |
| REC          | Renewable energy consumption    | Percentage of total final energy | WDI                       |
| GPRI         | Geopolitical risk index         | Frequency of newspaper articles containing “geopolitics”-related words | Policy uncertainty, com |

**References**

Abid M (2016) Impact of economic, financial, and institutional factors on CO2 emissions: evidence from Sub-Saharan Africa economies. Util Policy 41:85–94

Adams S, Adedoyin F, Olaniran E, Bekun FV (2020) Energy consumption, economic policy uncertainty and carbon emissions; causality evidence from resource rich economies. Econ Anal Policy 68:179–190

Akadiri S, Saint EKK, Akadiri AC, Avci T (2020) Does causality between geopolitical risk, tourism and economic growth matter? Evidence from Turkey. J Hosp Tour Manag 43:273–277. [https://doi.org/10.1016/j.jhtm.2019.09.002](https://doi.org/10.1016/j.jhtm.2019.09.002)

Al Mamun M, Uddin GS, Suleman MT, Kang SH (2020) Geopolitical risk, uncertainty and Bitcoin investment. Physica A. Phys A Stat Mech Appl 540:123107

Al-Mulali U, Ozturk I (2016) The investigation of environmental Kuznets curve hypothesis in the advanced economies: the role of energy prices. Renew Sustain Energy Rev 54:1622–1631. [https://doi.org/10.1016/j.rser.2015.10.131](https://doi.org/10.1016/j.rser.2015.10.131)

Algamdi A, Brika SKM, Musa A, Chergui K (2021) COVID-19 deaths cases impact on oil prices: probable scenarios on Saudi Arabia economy. Frontiers in Public Health 9(6):620875

Ali S, Dogan E, Chen F, Khan Z (2020) International trade and environmental performance in top ten emitters-countries: the role of eco-innovation and renewable energy consumption. Sustainable Development.

Alola AA, Bekun FV, Sarkodie SA (2019) Dynamic impact of trade policy, economic growth, fertility rate, renewable and non-renewable energy consumption on ecological footprint in Europe. Sci Total Environ 685:702–709

Alsagr N, van Hemmen S (2021) The impact of financial development and geopolitical risk on renewable energy consumption: evidence from emerging markets. Environ Sci Pollut Res 28(20):25906–25919

Anser MK, Syed QR, Apergis N (2021a) Does geopolitical risk escalate CO2 emissions? Evidence from the BRICS countries. Environ Sci Pollut Res Int 28(35):48011–48021

Anser MK, Syed QR, Lean HH, Alola AA, Ahmad M (2021b) Do economic policy uncertainty and geopolitical risk lead to environmental degradation? Evidence from Emerging Economies Sustainability 13(11):5866

Anser MK, Apergis N, Syed QR et al (2021c) Exploring a new perspective of sustainable development drive through environmental Phillips curve in the case of the BRICST countries.

Envir Sci Pollut Res 28:48112–48122. [https://doi.org/10.1007/s11356-021-14056-5](https://doi.org/10.1007/s11356-021-14056-5)

Aruga K, Islam M, Jannat A (2020) Effects of COVID-19 on Indian energy consumption. Sustainability 12(14):5616

Ayyo C (2020) Towards energy security for the twenty-first century. Energy policy. Intech Open, London 15–40

Balcilar M, Bonato M, Gupta DR, R, (2018) Geopolitical risks and stock market dynamics of the BRICS. Econ Syst 42(2):295–306

Baloch MA, Wang B (2019) Analyzing the role of governance in CO2 emissions mitigation: the BRICS experience. Struct Chang Econ Dyn 51:119–125

Bello MO, Solarin SA, Yen YY (2018) The impact of electricity consumption on CO2 emission, carbon footprint, water footprint and ecological footprint: the role of hydropower in an emerging economy. J Environ Manage 219:218–230. [https://doi.org/10.1016/j.jenvman.2018.04.101](https://doi.org/10.1016/j.jenvman.2018.04.101)

Bildirici M (2017a) CO2 emissions and militarization in G7 countries: panel cointegration and trivariate causality approaches. Environ Dev Econ 22(6):771

Bildirici M (2017b) The causal link among militarization, economic growth, CO2 emission, and energy consumption. Environ Sci Pollut Res 24(5):4625–4636

Bildirici M (2017c) The effects of militarization on biofuel consumption and CO2 emission. J Clean Prod 152:420–428

Bildirici M (2020) Terrorism, environmental pollution, foreign direct investment (FDI), energy consumption, and economic growth: Evidences from China, India, Israel, and Turkey. Energy & Environment (0958305X20919409)

Bildirici M, Gokmenoglu SM (2020) The impact of terrorism and FDI on environmental pollution: evidence from Afghanistan, Iraq, Nigeria, Pakistan, Philippines, Syria, Somalia, Thailand and Yemen. Environ. Impact Assess. Rev 81:106340

Bilgili F, Koçak E, Bulut Ü (2016) The dynamic impact of renewable energy consumption on CO2 emission, carbon footprint, water footprint and ecological footprint: the role of hydropower in an emerging economy. J Environ Manage 219:218–230. [https://doi.org/10.1016/j.jenvman.2018.04.101](https://doi.org/10.1016/j.jenvman.2018.04.101)

GPRI, Global Footprint Network; WDI, World Development Indicators.

Environ Sci Pollut Res 28:48112–48122. [https://doi.org/10.1007/s11356-021-14056-5](https://doi.org/10.1007/s11356-021-14056-5)

Aruga K, Islam M, Jannat A (2020) Effects of COVID-19 on Indian energy consumption. Sustainability 12(14):5616

Ayyo C (2020) Towards energy security for the twenty-first century. Energy policy. Intech Open, London 15–40

Balcilar M, Bonato M, Gupta DR, R, (2018) Geopolitical risks and stock market dynamics of the BRICS. Econ Syst 42(2):295–306

Baloch MA, Wang B (2019) Analyzing the role of governance in CO2 emissions mitigation: the BRICS experience. Struct Chang Econ Dyn 51:119–125

Bello MO, Solarin SA, Yen YY (2018) The impact of electricity consumption on CO2 emission, carbon footprint, water footprint and ecological footprint: the role of hydropower in an emerging economy. J Environ Manage 219:218–230. [https://doi.org/10.1016/j.jenvman.2018.04.101](https://doi.org/10.1016/j.jenvman.2018.04.101)

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Bildirici M (2017c) The effects of militarization on biofuel consumption and CO2 emission. J Clean Prod 152:420–428

Bildirici M (2020) Terrorism, environmental pollution, foreign direct investment (FDI), energy consumption, and economic growth: Evidences from China, India, Israel, and Turkey. Energy & Environment (0958305X20919409)

Bildirici M, Gokmenoglu SM (2020) The impact of terrorism and FDI on environmental pollution: evidence from Afghanistan, Iraq, Nigeria, Pakistan, Philippines, Syria, Somalia, Thailand and Yemen. Environ. Impact Assess. Rev 81:106340

Bilgili F, Koçak E, Bulut Ü (2016) The dynamic impact of renewable energy consumption on CO2 emissions: a revisited environmental Kuznets curve approach. Renew Sustain Energy Rev 54:838–845. [https://doi.org/10.1016/j.rser.2015.10.080](https://doi.org/10.1016/j.rser.2015.10.080)

Bhowmik R, Syed QR, Apergis N et al (2021) Applying a dynamic ARDL approach to the Environmental Phillips Curve (EPC) hypothesis amid monetary, fiscal, and trade policy uncertainty in the USA. Environ Sci Pollut Res. [https://doi.org/10.1007/s11356-021-16716-y](https://doi.org/10.1007/s11356-021-16716-y)

Böllük G, Mert M (2015) The renewable energy, growth and environmental Kuznets curve in Turkey: an ARDL approach. Renew Sustain Energy Rev 52:59–59. [https://doi.org/10.1016/j.rser.2015.07.138](https://doi.org/10.1016/j.rser.2015.07.138)

Bompard E, Carpiignano A, Erriguez M, Grosso D, Pession M, Profumo F (2017) National energy security assessment in a geopolitical perspective. Energy 130:144–154
eight developing countries of Asia. J Clean Prod 285:104277. https://doi.org/10.1016/j.jclepro.2020.124867
Sharma R, Sinha A, Kautish P (2021) Does renewable energy consumption reduce ecological footprint? Evidence from eight developing countries of Asia. J Clean Prod 285:124867
Sinha A, Gupta M, Shahbaz M, Sengupta T (2019) Impact of corruption in public sector on environmental quality: implications for sustainability in BRICS and next 11 countries. J Clean Prod 232:1379–1393. https://doi.org/10.1016/j.jclepro.2019.06.066
Sinha A, Shahbaz M, Balsalobre D (2017) Exploring the relationship between energy usage segregation and environmental degradation in N-11 countries. J Clean Prod 168:1217–1229. https://doi.org/10.1016/j.jclepro.2017.09.071
Sweidan OD (2021) The geopolitical risk effect on the US renewable energy deployment. Journal of Cleaner Production 293: 126189
Syed QR, Bouri E (2021) Impact of economic policy uncertainty on CO2 emissions in the US: evidence from bootstrap ARDL approach. Journal of Public Affairs e2595
Syed QR, Bouri E, Zafar RF, Adekoya OB (2021) Does geopolitical risk mitigate inbound tourism? Evidence from panel quantile regression. J Public Aff e2784
Tuna G, Tuna VE (2019) The asymmetric causal relationship between renewable and non-renewable energy consumption and economic growth in the ASEAN-5 countries. Resour Policy 62:114–124. https://doi.org/10.1016/j.resourpol.2019.03.010
Wang J, Dong K (2019) What drives environmental degradation? Evidence from 14 Sub-Saharan African countries. Sci Total Environ 656:165–173. https://doi.org/10.1016/j.scitotenv.2018.11.354
Wang Q, Su M (2020) A preliminary assessment of the impact of COVID-19 on environment—a case study of China. Science of the total environment 728:138915
Warr BS, Ayres RU (2010) Evidence of causality between the quantity and quality of energy consumption and economic growth. Energy 35(4):1688–1693
Westerlund J (2007) Testing for error correction in panel data. Oxford Bull Econ Stat 69(6):709–748
Yergin D (2006) Ensuring energy security. Foreign affairs 8(69):82
Zafar MW, Mirza FM, Zaidi SAH, Hou F (2019) The nexus of renewable and nonrenewable energy consumption, trade openness, and CO2 emissions in the framework of EKC: evidence from emerging economies. Environ Sci Pollut Res 26(15):15162–15173. https://doi.org/10.1007/s11356-019-04912-w
Zhang Z, Xi L, Bin S, Yuhuan Z, Song W, Ya L, Hao L, Yongfeng Z, Ashfaq A, Guang S (2019) Energy, CO2 emissions, and value added flows embodied in the international trade of the BRICS group: a comprehensive assessment. Renew Sustain Energy Rev 116:109432. https://doi.org/10.1016/j.rser.2019.109432
Zhao W, Zhong R, Sohail S, Majeed MT, Ullah S (2021) Geopolitical risks, energy consumption, and CO2 emissions in BRICS: an asymmetric analysis. Environ Sci Pollut Res Int 28(29):39668–39679

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