Linkage of natural resources, economic policies, urbanization, and the environmental Kuznets curve

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Abstract
Natural resource rents (NRR) and economic policies are considerably studied to determine ecological footprints. Currently, due to global uncertainty, renewable energy adoption, and increasing urbanization, every economy is facing challenges to control its ecological footprints. The available literature on the said linkages in the emerging seven economies is inconclusive. Therefore, this study is designed to re-estimate the linkages of NRR, urbanization (URB), economic policy uncertainty (EPU), energy structure (ES), and EFP under the “Environment Kuznets Curve (EKC) hypothesis.” Data from 1992 to 2020 is used for empirical evidence, along with robust econometric calculations. The EKC hypothesis does not apply to the E7 economies, according to the findings. The energy structure is assisting in limiting ecological footprints and hence aids in environmental cleanup. The role of NRR, EPU, and URB in limiting the EF, on the other hand, is not encouraging. To minimize environmental degradation, emerging economies should reconsider their economic policies, natural resource rents, and rapid urbanization.

Keywords Uncertain economic policies · Natural resource rents · Urbanization · Energy structure · Ecological footprints

Introduction
Climate change is the most widely discussed and evolving environmental problem that has effects at the global level. The United Nations focused on social welfare and sustainable development by putting significant emphasis on environmental degradation through sustainable development goals (UN 2019). Sustainable development, improving environmental quality, and escalation in social welfare are among the higher strategic choices for organizations. Therefore, the tradeoff between improving environmental quality and economic growth has led the policymakers to a crossroads. They have to determine key factors that are causing environmental issues but also have to ensure sustainable growth by taking initiatives to curb environmental degradation. With attention to climate action planned by the United Nations (UN), the world also needs to be ready for uncertain economic conditions. Recent uncertainty due to the outrage of COVID-19 also warned the world to formulate policies that can manage the uncertainties. Therefore, environmental degradation and economic policy uncertainty (EPU) are major challenges for the globe (Xu et al. 2022a; Yu et al. 2021). Moreover, the available resources may help to face these challenges successfully. Natural resources are viewed as
substantially important for the sustainable environment and economy (Ling et al. 2021). However, the energy structure is also relevant to achieving a sustainable environment. Therefore, the objective of this study is to empirically re-estimate the linkage of natural resources, uncertain economic policies, urbanization, energy structure, urbanization, and ecological footprints in an important group of emerging seven countries.

Natural resource rents are found to be an incentive for the developing countries, and in this attraction, many resource-rich countries compromise the environment (Dogan et al. 2020a, b). High-income resource-rich countries have transformed their resources in such a way that can be reaped as a blessing for a sustainable environment and economy (Hussain et al. 2021). However, developing countries are still struggling with their available resources. Moreover, another challenge faced by the world is to manage uncertain economic policies for sustainable development and a clean environment. According to recent studies on economic policy uncertainty (EPU), it is a serious issue to be considered to control environmental degradation (Hussain et al. 2022; Syed et al. 2022). In developing countries, uncertain economic policies lead to confused investors and manufacturers about their returns. In this situation, they try to raise their returns irrespective of the outcomes, so environmental regulations are compromised (Amin and Dogan 2021; Danish et al. 2020a). Therefore, the role of natural resources and uncertain economic policies to determine ecological footprints is interesting to re-estimate in emerging economies.

Furthermore, energy’s role can never be ignored by any economy. As the world is moving toward renewable energy options, energy structure may help to bring a sustainable environment. There are a large number of studies available on the role of renewable energy and ecological footprints in emerging economies (Danish and Ulucak 2021; Mehmood 2022; Yang et al. 2022; Zeraibi et al. 2021). Growing urbanization is increasing the demand for energy sources. Consequently, every economy has to plan additional energy sources to cope with urbanization. Additionally, urbanization occupies the available biocapacity of the geographical boundary of a country. Due to continuous urbanization, the ecological footprints may suffer. Available studies have estimated the role of urbanization to determine the environment (Du et al. 2019; Du et al. 2012; Ozturk et al. 2016). However, the literature is continuously growing. Along with the natural resources, uncertain economic policies, and urbanization, the impact of energy structure is uncommonly estimated in emerging seven economies.

Countries including “Brazil, China, India, Indonesia, Mexico, Russia, and Turkey” are combinedly known as emerging seven (E7). These economies are rapidly expanding, and they are likely to cross the G7 (Gövdeli 2019). They are predicted to contribute 25% of the global economy between 2015 and 2050, with an annual average growth rate of 3.5%, compared to the G7 countries’ 1.6%. E7 countries also use more energy and have increased their CO2 emissions from 26% in the early 1990s to 41% in 2018 (BP 2018). Furthermore, rapid growth in all sectors results in increased natural resource use, renewable energy production, urbanization, and ecological deficit problem. Moreover, due to uncertainty in the world, the E7 economies are also disturbed. As E7 economies are major exporters to the world, the high manufacturing and slow transition to renewable energy have influenced the ecological footprints.

So, empirical re-estimation of the level of ecological footprints in this region may add and bring value to the available knowledge in these ways. At first, the objective is to look at the empirical impact of natural resource rents, energy structure, urbanization, and economic policy uncertainties on the ecological footprint in E7 countries. Furthermore, the relationships are estimated using robust econometric estimations. These estimates are the “CSD test for cross-sectional dependence, panel unit root test, i.e., CIPS test for stationarity, Panel co-integration test, grouped FMOLS and grouped DOLS tests, and AMG tests.” These are the recommended econometric estimations and are widely used in the existing literature.

Upcoming parts of the study comprised of detailed literature, theoretical background, model construction, econometric techniques, results and discussions, and conclusion.

**Literature review**

Literature is reviewed in the form of individual nexus by critically analyzing the previous studies and to build a rationale for the current study.

**Ecological footprints and natural resource rents’ nexus**

“Natural resources rents include rents from minerals, coal, natural gas, oil, and forest. Natural resources rent includes all the sum of hard and soft payments from minerals, coal, natural gas, oil, and forest rents that are calculated as the difference between the cost of producing the resource and the price of the resource” (Hussain et al. 2020a, b, c). Climate change has driven more attention to natural resource rents as new schools of economics like environmental economics, ecological economics, and energy economics are taking place to investigate natural resources from different dimensions (Miao et al. 2022; Zafar et al. 2019b). Furthermore, several previous studies have been carried out to explore the fundamental connection between natural resource rent and ecological footprint that find positive relation (Awosusi et al. 2022; Hassan et al. 2019). But, on the other hand,
others have found a negative relation between ecological footprint and economic resource rent (Ulucak and Khan 2020). Additionally, natural resources through financial globalization and renewable energy help to achieve a sustainable environment in newly industrialized economies (Miao et al. 2022). Similarly, in a study of the MINT countries, the role of natural resource rents is found to be harmful because it causes to increase in carbon emissions (Aziz et al. 2021). Furthermore, the time-varying and dynamic effect of natural resources are checked against the level of carbon emissions by Ling et al. (2021). They found that the negative shocks of natural resources have a substantially positive impact on carbon emissions in China. The executives of developing countries are more fascinated to attract foreign direct investment for industrial production and economic growth at the cost of natural resource rents (Ahmed et al. 2020). Developing countries are more concerned about an increase in production and exports of goods and services, expansion of trade, and increasing the opportunities for employment for the people rather than the environment at an early stage of development (Wu et al. 2021). But the problem is more grief in the same economies. Such as Danish et al. (2020b) in their study explored that the ecological footprint in the BRICS countries is reduced by natural resource rents, whereas Nathaniel et al. (2020) discover contradictory results and conclude that natural resource rents rise the ecological footprint in the same countries. These results may vary subject to several factors, for example, sample size, the methodology adopted the time frame of a study, and additional covariates. But these contradictory results call for further investigation to explore the exact relationship between natural resource rents and environmental footprint as previous results are inconclusive.

**Urbanization and ecological footprints’ nexus**

Urbanization is among the most influential factors that affect the EFP and has gotten much attention from academia. Several studies have measured urbanization in connection with EFP. For instance, Baloch et al. (2019) studied the Belt and Road countries for the period 1990 to 2016 and found that urbanization and economic growth do not re-pollute the environment and increase the economic footprint. Similarly, another study was carried out by Nathaniel et al. (2020) in Indonesia that considers the period from 1971 to 2014 and concluded that urbanization and economic growth both add to EFP. Likewise, a study carried out in MINT (Malaysia, Indonesia, Nigeria, and Turkey) countries from 1971 to 2013 resolved the problem of EFP by pointing out urbanization, export, and consumption of fossil fuels as the main felons (Dogan et al. 2019). But contrary to the above studies, the work of Bello et al. (2018) has different results. They carried out research in the Malaysian context and concluded that urbanization has no harmful effects on the environment. Similarly, Ahmed et al. (2020) observed the connection between ecological footprint and urbanization in G7 countries by applying robust techniques and concluded that urbanization and energy consumption increase the EFP. Likewise, Anwar et al. (2021) found the deteriorating effect of urbanization on carbon emissions in selected Asian economies. These contradictory findings of several renowned studies have ignited us to explore the factual and robust connection between urbanization and EFP. Therefore, one of the objectives of this study is to re-estimate the impact of urbanization on ecological footprints in the E7 countries.

**Economic policy uncertainty, carbon emissions, and ecological footprints’ nexus**

Uncertainty is an important part of a study of economic policies, and detrimental effects of uncertainty have been seen through the lenses of fiscal, monetary, and regulatory policy uncertainty (Bachmann et al. 2013; Zhou et al. 2022). But economic uncertainty-related concepts and policies have gained remarkable attention after the global financial crisis of 2008–2009. Keeping in view the importance of economic policy uncertainty (EPU), Baker et al. (2016) developed an index that highlighted three main sources of uncertainty: “first is the number of news related to fiscal and monetary policy in media, and second is the number of tax code provisions, and, third is the agreement and disagreement of forecaster for government purchases and inflation in future.” The studies that used this index showed that EPU negatively affects both corporate investment at the micro-level and economic growth at the macro level. In a study carried out in G7 countries measured by real output divulges, those rumors and positive affirmation of EPU lead to declined economic activities and growth (Istiak and Serletis 2018). Additionally, Adedoyin et al. (2021) considered the long-run relationship between ecological footprints and economic policy uncertainty along with other variables from the top ten countries earning from tourism from 1995 to 2015 and found that energy consumption and economic policy uncertainty are associated with environmental degradation and ecological footprints.

Moreover, EPU and carbon emissions are studied in the USA by using bootstrap ARDL and found that EPU is responsible for high CO2 emissions in the short and long run (Syed and Bouri 2021). However, they only studied EPU in the USA and the current study is targeting this phenomenon in the emerging economies. Moreover, the role of natural resource rents, urbanization, and energy structure is also considered in this study. Although Anser et al. (2021) and Syed et al. (2022) investigated the role of EPU and geopolitical risk to determine ecological footprints and carbon emissions in emerging five and the BRICS economies and they found the deteriorating
role of EPU toward ecological footprints and carbon emissions, however, they did not consider natural resources and urbanization in their study. Therefore, the current study is designed to re-estimate the phenomenon in the emerging seven economies with long data. Therefore, the current study is an effort to add value to the existing knowledge by re-estimating the EPU and EFP in the E7 group of countries.

**Energy structure and ecological footprint**

“Energy structure is a part of total energy in the form of renewable energy sources.” Amin and Dogan (2021) explain it, “as a share of renewable energy consumption in total energy.” As the problem of environmental degradation magnifies, the importance of renewable energy is recognized. Several scholarly including explored the linkage between energy structure and ecological footprint/carbon emissions (Apergis et al. 2010; Aziz et al. 2020; Dogan and Seker 2016; Emre Caglar 2020; Sinha et al. 2019). Sharif et al. (2020) revisited the renewable energy and ecological footprints in Turkey by using the latest econometric estimations. They found the supportive role of RE to reduce EFP in Turkey. Recently, Ulucak and Khan (2020) estimate the relationship between renewable energy and the ecological footprint of BRICS countries and conclude that renewable energy is helpful. They advised the BRICS countries to shift to renewable and clean energy. Similar results were found in MENA countries by applying AMG estimator to renewable energy, urbanization, and financial development in the context of ecological footprint (Nathaniel et al. 2020). However, one study carried out by Alola and Kirikkaleli (2019) in European countries provides some different findings. Additionally, the role of clean energy and green financing is found to reduce environmental degradation in G7 countries (Yang et al. 2022). Prior studies have discovered that non-renewable energy has a positive effect on ecological footprint. These mixed results call for further investigation of the relationship between renewable energy structure and ecological footprint. Therefore, further investigation of the phenomenon in E7 economies may bring interesting outcomes. Moreover, to fill the little gap offered by a critical review of literature, the role of energy structure, natural resources, urbanization, and economic policy uncertainty is also estimated to determine the level of ecological footprint in E7 economies.

**Research methodology**

**Model construction**

The relationship between the environment and growth has received a lot of attention in the literature. Several studies have been carried out to re-examine the function of the growth environment in connection to a variety of economic indicators. However, it is imperative to acknowledge the revolutionary work of the Grossman and Krueger (1991; 1995) during the last decade of the twentieth century. Afterward, with the development of growth and environment literature, the role of natural resources and energy got the attention of economists. Natural resources are considered a substantial part of the economy who owns (Boschini et al. 2007; Razzaq et al. 2021a, b; Sun et al. 2021). The way of using natural resources decides the nature of blessings for the country. With the challenging situation of environmental degradation, the role of natural resources is also considerable (An et al. 2021; Chien et al. 2021; Miao et al. 2022; Sohag et al. 2019; Tang et al. 2022). Moreover, the role of energy is also essential for the smooth growth of every economy. To keep the environment clean, the adoption of renewable energy is a need of the hour. Literature has also acknowledged the need for renewable energy for a sustainable environment (Apergis et al. 2010; Destek and Manga 2021; Liu et al. 2021; Razzaq et al. 2021a, b; Sun and Razzaq 2022). Furthermore, the ever-increasing urbanization is also considered worth the climate action plan. Nonetheless, the role of economic policies is of utmost importance for the growth and environment. Economic policy uncertainty is a real challenge for the economy and environment. Therefore, the abovementioned factors are relevant to the environment of every economy. On the environmental side, the measurement of environmental degradation can be carbon emissions. A large number of studies used this proxy. However, a large body of literature supports the evidence of ecological footprints as a better way to monitor environmental degradation (Aşıcı and Acar 2016; Hussain et al. 2020a, b, c; Hussain and Dogan 2021; Rees 1996; Solarin et al. 2019; Wang and Dong 2019). Therefore, the present study is an extension of the existing literature on the “Environment Kuznets Curve (EKC).”

\[
EFP = f(Y + Y^2 + ES + NRR + EPU + URB) \quad (1)
\]

where EFP is “ecological footprint per capita consumption,” whereas (Y) is “gross domestic product (GDP) and is estimated as the current US$.” ES is “energy structure which is a part of total energy in the form of renewable energy sources,” (NRR) “is calculated as the GDP percentage of natural resource rents,” EPU “is economic policy uncertainty and it is taken from the EPUI generated by Economic Policy Uncertainty Index (2021),” and “urbanization (URB) estimates entire urban populations.” Data is taken from the WDI website and the “global footprints network.” The econometric from Eq. 1 can be written as follows:

\[
EFP_{it} = \beta_0 + \beta_1 Y_{it} + \beta_2 Y_{it}^2 + \beta_3 ES_{it} + \beta_4 NRR_{it} + \beta_5 EPU_{it} + \beta_6 URB_{it} + \mu \quad (2)
\]
Here, $\beta_0$ is the coefficient of regression, and it is the value of the dependent variable in the absence of any independent variables. Expected signs of $\beta_1$ and $\beta_2$ are positive, because the emerging seven economies are at the early development stage and the preference of these economies is to maximize the income irrespective of the environmental damage. Therefore, positive signs of coefficients of income level and its square can be assumed. Furthermore, $\beta_3$ is expected to be negative. The reasons for this assumption are based on the supportive nature of renewable energy toward the ecological footprints. Literature support also sporadically evident in this plea. Additionally, the coefficients of NRR, EPU, and URB are assumed to be positive. The literature support recommends their harmful impact on ecological footprints in the emerging economies. Therefore, the present study assumed $\beta_4, \beta_5,$ and $\beta_6 > 0$.

**Data period and econometric estimations**

The abovementioned model is empirically tested by using annual data from 1992 to 2020. Data sources are mentioned above under Eq. 1. To handle the possible issues of panel data, the recommended estimations are needed to apply. Endogeneity and cross-sectional dependence can be handled using econometric estimations. Cross-sectional dependency is measured using the CSD test, while stationarity is measured using the CIPS test. The following equations are representing the CSD test and the CIPS unit root tests:

$$\Delta x_t = \phi_r d_t + \theta_j x_{t-1} + \phi_x z_{t-1} + \sum_{j=1}^{n} \theta_j \Delta x_{t-j} + \omega_t$$ \hspace{1cm} (3)

$$\text{CIPS}(P, Y) = t - \text{bar} = P^{-1} \sum_{i=1}^{p} t_i(P, Y)$$ \hspace{1cm} (4)

After the checking of cross-section dependence and stationarity of the panel data, the next recommended test is to estimate co-integration. So, panel co-integration proposed by Westerlund (2007) is applied. Furthermore, after the confirmation of the co-integration, the long-run influence of the exogenous variables is estimated. For this, “grouped Fully Modified Ordinary Least Square (FMOLS) and Dynamic (DOLS) tests” are selected. Moreover, to check the robustness of the estimations, “Augmented Mean Group (AMG)” estimation is also applied.

**Results and discussions**

Table 1 shows the correlation and CSD estimations’ results. The correlation values are showing that EFP, Y, NRR, ES, EPU, and URB are interconnected. The $p$-value for all variables is less than 0.01 in all cases, indicating that they are cross-sectionally dependent. The CIPS unit root tests are used to determine the data’s stationarity. Table 2 shows the findings of the CIPS unit root test, which show that a few variables are stationary at level, and after taking the first difference, all variables become stationary. Furthermore, the results of co-integration are shown in Table 3. All variables are co-integrated in the long term.

As mentioned above in the econometric estimations section, the FMOLS, DOLS, and AMG econometric estimations are applied and the results are available in Tables 4 and 5. According to the reported results, with the predicted signs of the coefficients, all variables are statistically significant. Despite the small magnitude of the Y&Y2 coefficients, they are statistically significant in all estimations. It means that these estimations are robust. In the case of E7 economies, the EKC hypothesis is invalidated because the $Y^2$'s coefficient is positive. Next, in the case of ES, the results are statistically significant with negative coefficients in DOLS,

| Table 1 Correlation and CSD statistics | Variables | CD-test | $p$-value | Correlation |
|---------------------------------------|-----------|---------|-----------|-------------|
| EFP                                  | 20.789*** | 0.000   | 0.678     |
| Y                                    | 87.138*** | 0.000   | 0.687     |
| ES                                   | 54.124*** | 0.000   | 0.671     |
| NRR                                  | 52.113*** | 0.000   | 0.589     |
| EPU                                  | 88.567*** | 0.000   | 0.611     |
| URB                                  | 58.321*** | 0.000   | 0.822     |

*** is significant @ 1%


Table 4  DOLS and FMOLS results for EFP

| Variables | FMOLS Coef | p-value | DOLS Coef | p-value |
|-----------|------------|---------|-----------|---------|
| Y         | 0.081*     | 0.000   | 0.077*    | 0.000   |
| Y^2       | 0.121*     | 0.000   | 0.106*    | 0.000   |
| ES        | −0.293*    | 0.000   | −0.339*** | 0.000   |
| NRR       | 0.211*     | 0.000   | 0.377*    | 0.000   |
| EPU       | 0.383*     | 0.000   | 0.377*    | 0.000   |
| URB       | 0.291*     | 0.000   | 0.234*    | 0.000   |

* is 5% significance level

Table 5  Augmented mean group estimations for EFP

| Variables | Coefficient | p-value |
|-----------|-------------|---------|
| Y         | 0.289*      | 0.000   |
| Y^2       | 0.189*      | 0.000   |
| ES        | −0.179*     | 0.000   |
| NRR       | 0.357*      | 0.002   |
| EPU       | 0.101*      | 0.008   |
| UEB       | 0.239*      | 0.000   |
| Const     | −0.118      | 0.123   |

* is a 10% significance level

FMOLS, and AMG. It means that energy structure is helpful to reduce ecological footprints in E7 economies. Previous studies have shown similar results (Bilal et al. 2022; Hussain et al. 2022).

Tables 4 and 5 also include the results of NRR, EPU, and URB. The long-run coefficients of NRR, EPU, and URB are all significant and positive, indicating that the use of natural resources hurts ecological footprints and harms the ecosystem in the E7 region. Similarly, the influence of EPU and URB on the environment is determined to be damaging, as seen by the positive coefficients of both in the results. As a result, the degree of ecological footprint in emerging economies is increasing as a result of economic policy uncertainty and increased urbanization (Amin and Dogan 2021; Xu et al. 2022a; Zafar et al. 2019a).

This section of the study delves into the findings and their practical consequences. It is important to remember that EF is a measure for measuring environmental damage. Nonetheless, starting the EKC’s absence in this panel means that these economies are at early development stages and hence environment is ignored. Simply put, the current rate of economic expansion is creating an increase in environmental deterioration. Also investigated is the effect of energy structure on environmental degradation. The coefficient of ES is found to be negative and significant in the long-run findings of DOLS, FMOLS, and AMG. Energy structure is helpful to reduce environmental footprints. Investing in renewable energy has the potential to pay off for investors. So, the E7 economies should improve their renewable energy investment percentage (Amin and Dogan 2021; Hussain et al. 2020a, b, c; Luan et al. 2022). This study also looks at the effect of natural resource rents, economic policy uncertainty, and urbanization on environmental degradation. Empirical results revealed the positive and statistically significant coefficients of NRR, EPU, and URB in explaining EF. These findings indicate that these three variables have a detrimental impact. As a result, to reduce the negative effects of natural resource rents and urbanization, emerging economies must actively address economic policy uncertainties. Urbanization can help to clean the environment if it is planned in such a way that it decreases ecological footprints. Only if new housing societies are developed with targeted urbanization in mind will this be possible. Furthermore, the use of natural resource rents should assist emerging economies in implementing specific economic policies.

Conclusion

After the discussion of the findings obtained through empirical results, it can be concluded that economic policy uncertainty, natural resource rents, urbanization, and energy structure are substantially affecting ecological footprints in E7 economies. Moreover, the EKC hypothesis is invalid for this group of economies. Annual data from 1992 to 2020 is used for empirical support. Robust econometric approaches, which are evident in dealing with panel data difficulties, are used to estimate the postulated links.

Findings have a lot of policy implications. To begin with, shifting the energy structure away from fossil fuels and toward renewable sources may benefit the emerging seven economies. Second, to limit ecological footprints, uncertain economic policies and urbanization should be proactively regulated. With the increasing urbanization, the ecological deficit is increasing, so, instead of horizontal spread, skyscrapers may help to reduce the impact of urbanization in emerging economies. Moreover, natural resources should be wisely used for long-run plans. Merely the exports of raw resources may harm the economy and environment at the same time.

Third, economic policies should be planned in such a way as to tackle unforeseen events. For example, the COVID-19 issue affected the global economies. However, if the economic policies are designed flexibly, the impact of uncertain events can be minimized.

The paper has some limitations, which may serve to widen the literature. To begin, this study considers the overall function of energy structure, which may deceive the ecological footprints; subsequent studies can examine the sub-parts of renewables individually to determine the actual

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contribution to cleaning the environment. In addition, the function of justice in the transformation process could provide fascinating results. Second, the function of economic policies in regulating urbanization and the role of natural resource rents in environmental deterioration may become clearer.

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- Muzzammil Hussain: idea generation, econometric methodology, and editing.
- Ali Abbas: theoretical background and literature review
- Shahid Manzoor: introduction and literature
- Bilal: write-up and supervision
- Ye Chengang: supervision

Data availability Data will be provided on demand.

Declarations

Ethics approval and consent to participate The authors are giving ethical approval and consent for the said paper.

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