Challenges in Sustainability
https://www.acadlore.com/journals/CIS

Macroeconomic Policy Uncertainty and Environmental Sustainability Nexus: A Systematic Review

Haider Mahmood[1*], Ateeq ur Rehman Irshad[2]

[1] Department of Finance, College of Business Administration, Prince Sattam bin Abdulaziz University, 11942 Alkharj, Saudi Arabia
[2] Department of Mathematics and Sciences, Prince Sultan University, 11586 Riyadh, Saudi Arabia

[*] Correspondence: Haider Mahmood (haidermahmood@hotmail.com)

Received: 08-28-2025 **Revised:** 10-05-2025 **Accepted:** 11-19-2025

Citation: Mahmood, H. & Irshad, A. u. R., (2026). Macroeconomic policy uncertainty and environmental sustainability nexus: A systematic review. *Chall. Sustain.*, *14*(1), 16–36. https://doi.org/10.56578/cis140102.

Abstract: Recent literature has explored the nexus between macroeconomic policy uncertainty (MPU) and the environment in compliance with Sustainable Development Goals (SDGs). This study contributes to the literature by exploring the possible or negative environmental effects of MPU. The present study reviewed 117 research articles published from 2020 to 2025 to understand the multifaceted association between MPU and environmental sustainability, having considered sectoral and spatial dynamics, asymmetric responses, and heterogeneous responses from different countries and regions. The findings suggested that the relationship was complex, and varied upon the economic sector, emissions source, policy regime, and geographical location. MPU reduced the speed of transition from the first to the second phase of the Environmental Kuznets Curve (EKC). In the short run, MPU can reduce emissions due to temporary economic slowdowns. Nevertheless, it can be responsible for negative long-term environmental performance by delaying green investments, increasing fossil fuel reliance, and weakening institutional effectiveness. Sectoral analyses revealed that MPU raised emissions in the energy and industrial sectors and reduced them in the agricultural sector. While strong institutional quality helped to mitigate emissions, weak institutions raised environmental problems. The findings of this review suggested that policymakers should design adaptive, sector-sensitive, and regionally coordinated environmental strategies to protect the environment from macroeconomic policy volatility.

Keywords: Macroeconomic policy uncertainty; Sustainable Development Goals; SDGs; Environmental sustainability; Emissions

1. Introduction

Macroeconomic policy uncertainty (MPU) is a prominent factor that might affect both environmental sustainability and energy transitions (Wang et al., 2023). MPU describes the level of unpredictability of government macroeconomic policies, which can affect investment decisions, societal behaviors, economic activities, and the environment. In this regard, a lot of recent studies have investigated MPU and the environment nexus in the country-specific and panel studies. However, the literature has reported a mix of both positive and negative relationships between MPU and environmental outcomes. For instance, in times of high MPU, the business sector prefers survival and may not invest in Renewable Energy Generation (REG) (Hassan et al., 2022), as infrastructure of renewable energy is very expensive and time-consuming to install. Moreover, the private sector might stop investments in green technologies and delay long-term planning due to the volatility of energy prices (Ali et al., 2023). This perception would increase the dependence of the business sector on fossil fuels, which may increase emission levels and reduce environmental quality. Similarly, MPU also influences the energy sector to keep its dependence on fossil fuels instead of investing in REG (Appiah-Otoo, 2021). Thus, MPU can be responsible for pollution emissions and is a hurdle to local and global environmental targets.

In the short run, it is expected that the positive environmental outcomes of MPU could reduce industrial and economic activities, energy consumption, and pollution due to overall low investments in the business sector. At the consumption level, households may increase precautionary savings to combat the expected economic crisis during MPU, which can reduce demand for goods and services. In response, production activities, energy consumption, and pollution might be reduced. Moreover, MPU can reduce construction activities and directly help in the reduction of emissions from the construction sector. The financial sector may become more risk-averse in times of a high MPU (Ivanovski & Marinucci, 2021); it would reduce credit availability and overall economic activities. Lastly, MPU may weaken local and global trade due to the volatility of exchange rate (Selmey et al., 2024). It may also adversely affect transportation and other activities in the trading sector. Thus, the short-run effects of MPU can decrease aggregate demand, energy consumption, and pollution.

As per the above-discussed channels, MPU can have mixed effects on energy consumption, environmental outcomes, and the Renewable Energy Transition (RET). These effects may vary across sectors, regions, and governance contexts. Several review studies have examined the effect of economic policy uncertainty on different financial and economic indicators (Haq et al., 2021; Wang et al., 2024b; Wüstenfeld & Geldner, 2022). However, existing studies addressed uncertainty in narrow contexts by examining economic and financial outcomes. Specifically, the effect of MPU on environmental sustainability and the RET was not reviewed. Therefore, the present study aims to fill this literature gap by critically and comprehensively reviewing and synthesizing the channels that are responsible for shaping the connection between MPU, the environment, and the RET. For this purpose, the study utilized a systematic review approach and selected 117 studies from the Scopus database. The findings provided a deeper understanding of how MPU could influence the industrial and energy sectors by suggesting policies for promoting sustainable development in the policy-volatile global economy.

2. Methodology

The Scopus database was used to collect the literature via a systematic review approach (Liberati et al., 2009). The Scopus database was chosen due to its coverage of abundant peer-reviewed journals, broad interdisciplinary scope, quick indexing, and advanced search tools. Thus, these merits of the Scopus database are more than the merits of Web of Science, Google Scholar, or any other databases. Specifically, Scopus provides comprehensive coverage in the business, management, environmental science, and economic domains. Our objective is to find the studies investigating the connection among MPU, the environment, and the energy sector by using different sectoral, spatial, and regional dynamics. Thus, we utilized the keywords (TITLE-ABS-KEY("environment" OR "environmental quality" OR "environmental degradation" OR "environmental sustainability" OR "ecological footprint" OR "pollution" OR "environmental impact" OR "environmental performance" OR "climate change" OR "global warming" OR "greenhouse gas emissions" OR "CO_2 emissions" OR "carbon footprint" OR "carbon intensity" OR "methane emissions" OR "air pollution" OR "renewable energy" OR "fossil fuel consumption" OR "energy transition" OR "energy consumption" OR "clean energy" OR "energy efficiency" OR "sustainable energy")) AND (TITLE-ABS-KEY("economic policy uncertainty" OR "EPU" OR "policy uncertainty" OR "economic policy shocks" OR "fiscal policy uncertainty" OR "monetary policy uncertainty")). Later, we applied some filters including "English", "Articles", "Journals", and "Economics, Econometrics, and Finance". After applying all filters, 345 articles were retrieved for detailed screening. Moreover, we focused on the articles published from 2020 to 2025.

The selection of research papers from 2020 to 2025 was justified by several critical global events, which were accountable for MPU and its effect on the environment. COVID-19 started in 2019 but its effect on fiscal and monetary policy interventions was realized in 2020. This event introduced uncertainty in policy directions and also influenced energy demand patterns, industrial activities, and pollution emissions. Similarly, geopolitical tensions, the Russia-Ukraine conflict, US-China trade frictions, and unrest in the Middle East have also contributed to MPU by disrupting global energy markets. For instance, these events were responsible for the fluctuation in oil prices, which also affected the RET landscape. Thus, these events may directly affect the MPU-environment nexus by altering investment flows toward green technologies, which could change carbon intensity but can increase the risks of energy insecurity. Moreover, inflationary pressures and interest rate shocks further compound MPU, which can affect investment decisions. Furthermore, the MPU dataset has undergone significant updates during 2020-2025 by increasing country-specific and sector-specific indices. Consequently, the literature on policy uncertainty expanded rapidly to analyze newly available datasets across different contexts. Hence, the focus on the period 2020-2025 allows us to synthesize the most recent developments and assess how evolving MPU arising from recent events could influence environmental sustainability worldwide.

We thoroughly read the abstracts and conclusions of filtered articles to choose the studies for investigating the linkages between MPU and environmental outcomes such as CO_2 emissions, energy consumption, the RET, ecological footprints, etc. We only selected studies on the macroeconomic environment and avoided studies at the firm level. Our selection criteria included empirical studies published in journals in English language regarding the area of "Economics, Econometrics, and Finance". We ignored review studies and other types of articles, as well as research articles published in languages other than English or disciplines other than "Economics, Econometrics, and Finance". Lastly, we selected 117 articles with a critical synthesis approach. Figures 1, Figure 2, and Figure 3 show some facts of bibliographic coupling and re-occurring keywords in the literature on economic policy uncertainty.

Figure 1 presents the re-occurring keywords analysis by VOSviewer software. It illustrates the intellectual structure of the literature by clustering keywords, which appear together in publications. The size of each node shows the frequency of keyword occurrence. The thickness of the connecting lines shows the strength of co-occurrence links. Different colors denote distinct clusters to reflect different thematic groups. The results showed that the keyword "economic policy uncertainty" was the most frequently occurring keyword, which represents its central role in current research on policy uncertainty. Moreover, "uncertainty analysis", "climate policy uncertainty", and "uncertainty" were among the most frequently re-occurring keywords in the literature, thus forming a strong core cluster and were linked with various environmental proxies. The focus of the literature was on the conceptualization and measurement of uncertainty. Other clusters showed some prominent nodes of "environmental policy", "energy transition", and "green finance"; this indicated that uncertainty was the most frequently investigated environmental and energy-related issues. A cluster with "volatility" and "uncertainty shocks" emphasized the methodological approaches used in the literature of policy uncertainty. The presence of "governance" explained the interdisciplinary extension of uncertainty studies in the institutional domain.

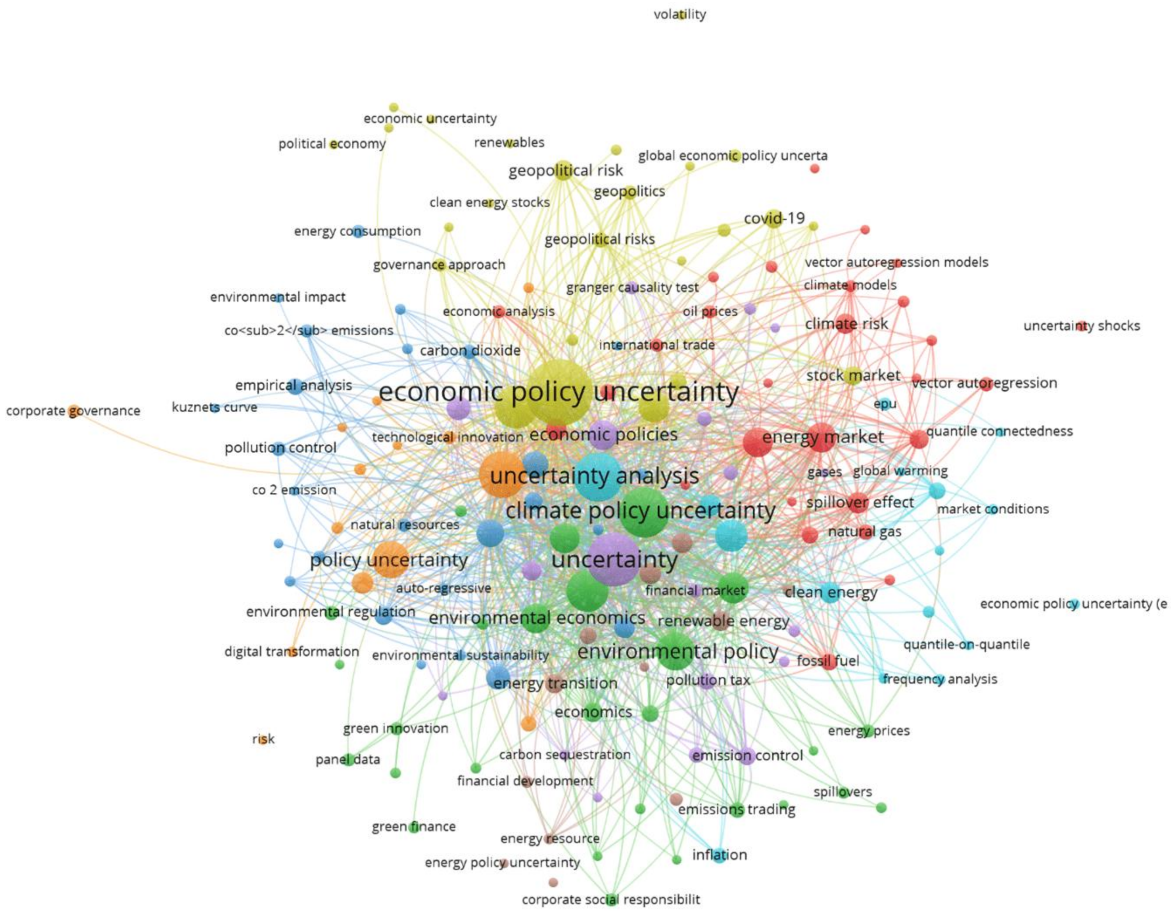

Figure 1. Re-occurring keywords

Figure 2 shows the bibliographic coupling of researchers' countries, indicating the geographical distribution and intellectual linkages of research contributions and common citations in the field of policy uncertainty. It shows the linkages of common citations in the publications of authors from different countries. China was found at the top of the list with the largest and most central node; authors from China occupied a central position in the citing of research on policy uncertainty. The strong bibliographic coupling of China with a wide range of countries reflects that Chinese authors are at the top in citing common references, thus showing the strong influence of Chinese authors in citing and shaping the global research on policy uncertainty, environmental sustainability, and energy transitions. The authors from the US also took a prominent and significant position as they had strong research and citation ties with authors in other advanced economies. The US also shows a strong contribution in citing policy uncertainty research. Apart from China and the US which dominated two strong positions, countries like the UK, Germany, Australia, and South Korea had significant nodes. These nodes highlight the active engagement of their authors, in terms of common citations, with those from other developed or emerging countries in different clusters.

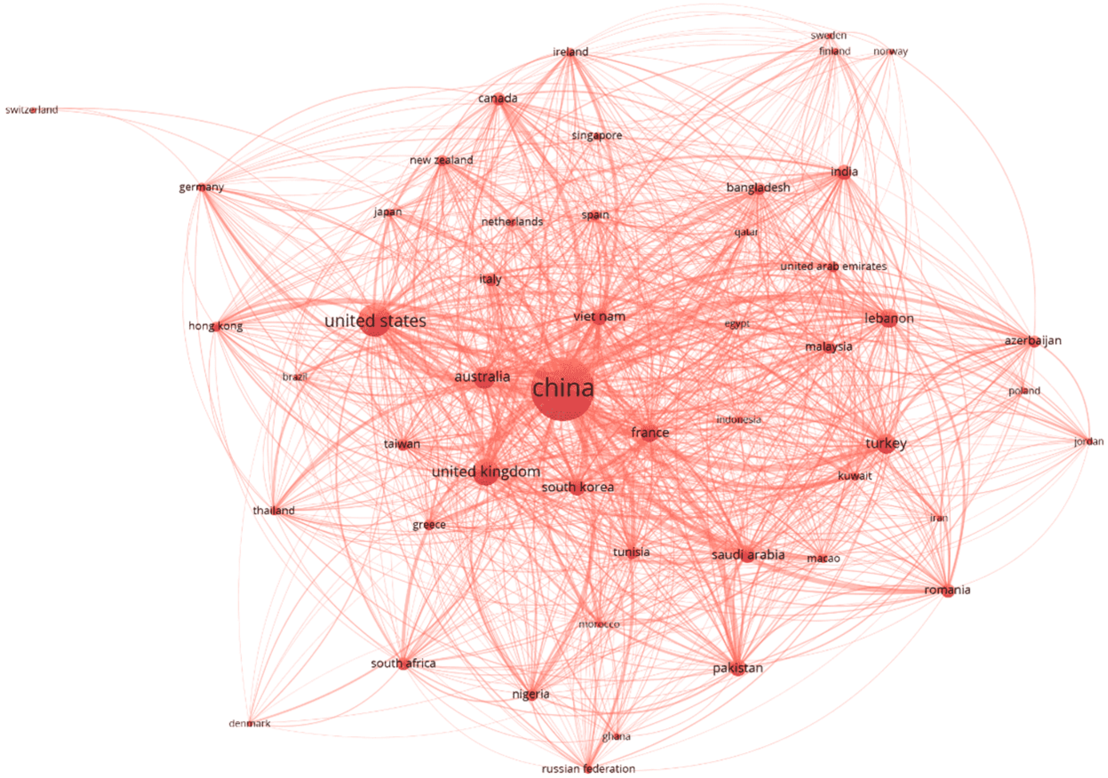

Figure 2. Bibliographic coupling based on researchers' countries

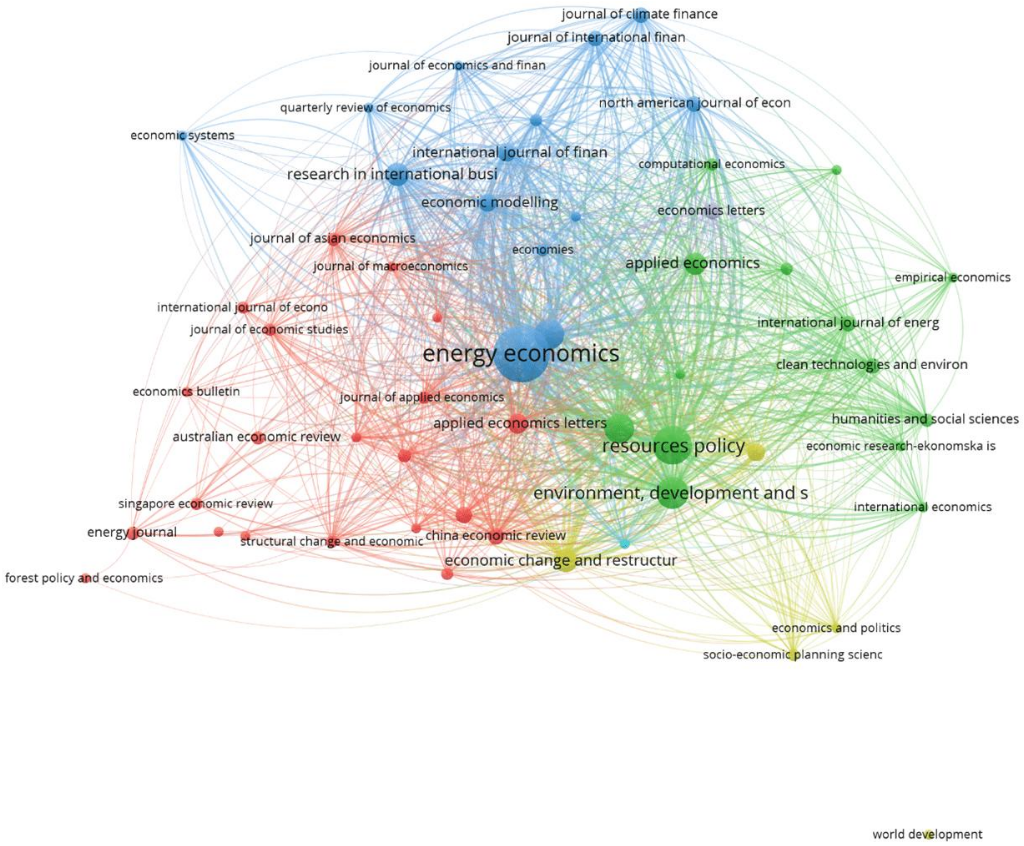

Figure 3. Bibliographic coupling based on journals

Figure 3 presents bibliographic coupling based on journals. The journal *Energy Economics* was found in a central place and also at the top of the list. This journal has cited common references, which have also been cited by other journals in the blue cluster. In the green cluster, "Resource Policy" and "Environment, Development, Sustainability" are carrying significant positions in terms of common citations, which have strong linkages with other journals by citing the same references in the green cluster. In the red cluster, no journal could achieve a significant position. However, *Applied Economic Letters* had a relatively better position in bibliographic coupling in comparison to other journals in the red cluster. Moreover, there is a large number of journals in the red cluster compared to the clusters of other colors. Many journals in the red cluster cited the same references in the domain of policy uncertainty. The journals with different scopes showed that the relationship between policy uncertainty, the RET, and the environment was a multidisciplinary topic and mostly published by journals in the domains of economics, energy, environment, and development.

3. Literature Review

This section explored the environmental effects of MPU across multiple dimensions in the literature. For instance, some studies examined this relationship in the Environmental Kuznets Curve (EKC) hypothesis. The literature also investigated the role of MPU in determining the RET, green innovation, and technological progress. The moderating effects of governance quality and institutional strength were discussed in some research. Having considered the different objectives stated in the selected studies, this section was then divided into five subsections.

3.1 MPU and the Environment in the EKC Framework

The EKC framework presents an inverted U-shaped effect of economic growth on environmental degradation. In the first phase, economies grow with industrialization, resource depletion, and fossil fuel consumption, which increases environmental degradation. However, in the second phase, economies grow with structural transformation and technological innovation, which helps improve the environmental quality. MPU can delay the transformation of the EKC from its first to second stage. For instance, MPU discourages long-term green investments, which may delay the reliance of an economy on fossil-fuel dependence. Secondly, MPU can be responsible for weakening the enforcement of environmental regulations, which may slow down the transition toward the second phase of the EKC. Thirdly, uncertainty amplifies risk premiums, which can raise the cost of financing renewable projects and can also delay the transition to the second phase of the EKC.

This subsection discussed those studies that investigated MPU and the environment nexus in the EKC framework. For instance, Barra et al. (2025) examined the EKC by incorporating economic, climate, and energy policy uncertainties and validated the EKC. The EKC was affected by institutional quality, MPU, and international commitments. However, countries with weak institutions could not achieve the EKC turning point due to a high level of MPU. Mushtaq et al. (2024) revealed the validity of the EKC in 22 countries from 1997–2021. MPU reduced green investments and increased emissions; it discouraged capital-intensive clean energy investments and increased fossil fuel consumption, which was a deviation from the projected second phase of the EKC. Balsalobre-Lorente et al. (2024) examined the G20 and concluded the EKC in carbon and ecological footprint models. MPU and economic complexity intensified pollution. However, Geopolitical Risk Index (GPR) and Regional Economic Communities (REC) contribute to environmental improvements. Işık et al. (2023) examined Brazil, Russia, India, and China (BRIC) and G7 countries and found that REC, economic freedom, and MPU delayed the EKC turning point in G7 economies. Thus, the EKC did not hold in the BRIC nations. Udeagha & Muchapondwa (2023) validated the EKC in South Africa, and fiscal decentralization and green innovation reduced emissions. Moreover, long-run MPU and globalization worsened environmental outcomes. Ali et al. (2022) examined BRICS countries and demonstrated that urbanization raised emissions and thus the EKC was validated. However, the long-term effect of MPU slowed down the transition of the EKC. Most studies in this subsection reported the adverse environmental effects of MPU.

Some studies also found the positive or mixed effects of MPU on the environment. For instance, Aslan et al. (2024) investigated the G7 and found that MPU reduced emissions due to declines in industrial activity in lower-middle quantiles. The EKC was substantiated. Cutcu et al. (2025) examined 17 economies and revealed that MPU improved environmental quality at lower pollution quantiles and reduced it at higher quantiles. This effect depended on threshold-specific EKC dynamics. Chu et al. (2023) analyzed the E7 economies and found that MPU and GPR degraded the environment in the short term. Long-term effects improved the environment through policy learning and institutional adaptation. The EKC model was found to be responsive to uncertainties.

Table 1 and Figure 4 provide a summary of the environmental effects of MPU in the EKC Framework. This subsection concluded that a high level of MPU generally proved to be a hurdle in the transition of the EKC from its first to the second phase. This result was particularly more pronounced in countries with weak institutions. Moreover, a high level of MPU was found to be responsible for low green investments.

Table 1. Environmental effects of MPU in the EKC framework

Environmental Effects of MPU	References	Regional Sample	Key Mechanisms
Positive	Aslan et al. (2024)	G7	EKC validated with MPU, to improve environmental quality by reducing industrial activities.
Negative	Ali et al. (2022); Balsalobre-Lorente et al. (2024); Barra et al. (2025); Işık et al. (2023); Mushtaq et al. (2024); Udeagha & Muchapondwa (2023)	22 countries, G20, G7, South Africa, and the BRICS	MPU discouraged green investments, increased fossil fuel use, delayed the EKC turning point, intensified pollution, and worsened long-term environmental outcomes.
Mixed	Chu et al. (2023); Cutcu et al. (2025)	17 countries and E7	The effects of MPU depend on pollution quantiles.

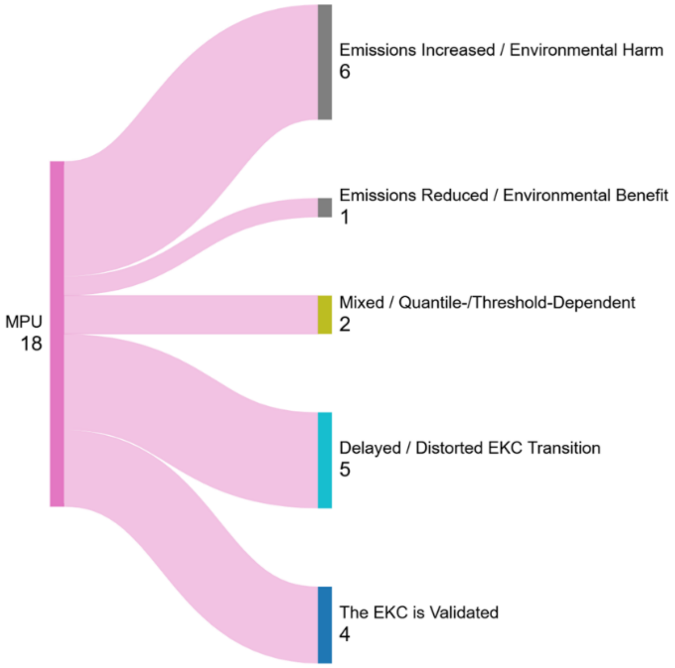

Figure 4. Role of MPU in the environmental outcomes and the EKC

3.2 MPU, Energy Sector, and Environmental Sustainability

Fossil fuel consumption is largely responsible for environmental degradation, and MPU can affect the energy-environment nexus. For instance, MPU may increase economic unpredictability and can reduce investments in clean technologies with higher perceived risks. MPU can discourage the RET by raising financial costs associated with perceived risk and weakening investor confidence. Moreover, it can weaken environmental governance by prioritizing short-term stabilization and energy security, thus ignoring long-term sustainability. MPU can increase resource misallocation and hamper the adoption of environmental regulations. On the other hand, MPU may motivate innovation, institutional reform, and adaptive strategies in response to uncertainty, which may promote the RET. Thus, MPU has the potential to reduce environmental problems.

Anser et al. (2024) examined Sub-Saharan Africa (SSA) and revealed that MPU reduced emissions by minimizing economic activities. Moreover, institutional variables played a critical role in mediating MPU effects. In the same vein, Chen & Nouseen (2025) found that institutional capacity promoted the RET in times of volatile MPU. In another study, Adedoyin et al. (2021) reinvestigated SSA and reported that MPU moderated the effects of REC and non-REC on emissions. MPU reduced environmental harm from non-REC and supported the environmental protection of REC. Selmey et al. (2024) found that MPU reduced emissions in BRICS whereas trade raised emissions. Ahmed et al. (2021) scrutinized the US and concluded that REC reduced emissions. Decreasing MPU amplified the effect of REC in reducing emissions.

Anser et al. (2021b) found that REC reduced ecological footprints even in the presence of MPU and GPR. Erzurumlu & Gozgor (2022) analyzed 72 countries from 1960 to 2016 and found that higher MPU reduced energy consumption. MPU showed a potential to disrupt energy consumption patterns and this was possible through energy policy and environmental sustainability. Ayad et al. (2023) analyzed the MENA region and found that extreme MPU decreased emissions. Zhang et al. (2023a) documented feedback effects among MPU, ecological innovation, globalization, and emissions. Moreover, he pointed out that MPU reduced emissions. Fang et al. (2025) investigated the US and found that the interaction of MPU with Artificial Intelligence (AI) improved the RET. Thus, uncertainty promoted creative adaptation. Dastgeer et al. (2023) reported that REC raised environmental quality, and its interaction with MPU also mitigated ecological degradation.

The literature also reported the adverse environmental effects of MPU. Kashif et al. (2025) reinvestigated the US economy and found that bioenergy reduced emissions. However, MPU and natural resource depletion minimized the pleasant effects of bioenergy. Chiou et al. (2025) scrutinized the US and found that MPU raised CO_2 emissions, which, in the long run, were affected by income growth and political problems. In another dimension, Ivanovski & Marinucci (2021) and Shafiullah et al. (2021) investigated the US and reported that MPU was negatively associated with REC over a long period. Li et al. (2025) found that MPU slowed down clean energy progress in Arctic Council nations in the early stage of the RET. However, this impact was curtailed by environmental technology and governance quality. Wang et al. (2024a) reported that MPU increased sectoral CO_2 emissions in medium and high quantiles. Thus, the effect of MPU differed in different sectors. Zhang et al. (2021) investigated BRICS and reported that MPU reduced REC. However, financial development (FD) and foreign direct investment (FDI) helped to reduce this effect. Owusu et al. (2024) analyzed the Nordic countries and reported that MPU and resource rents raised emissions. However, the RET reduced these effects.

Oryani et al. (2022) stated that green energy improved the environment in South Korea. However, MPU increased ecological degradation during economic transitions. Xu et al. (2024) stated that MPU raised fossil fuel usage and FD mitigated the adverse effects of MPU on energy consumption. Thus, FD and investment frameworks served as moderators. Adams et al. (2020) and Shabir et al. (2022) revealed the feedback between MPU and CO_2 emissions. MPU was affecting emissions while in turn environmental conditions and energy consumption were shaping policy uncertainty. Wei et al. (2023) scrutinized Russia and reported that MPU and economic expansion raised emissions. REC mitigated this effect. You et al. (2023) examined G-10 and reported that MPU increased ecological degradation. However, energy structure shifts and resource rents reduced environmental problems. Farouq & Sulong (2024) investigated the Organization of the Petroleum Exporting Countries (OPEC) nations and found that MPU and oil price volatility reduced REG investment, yet financial globalization enhanced it. Yi et al. (2023) reported that FD and globalization supported REC but MPU reduced it.

Selmey & Elamer (2023) investigated Egypt and found that greater economic policy stability and strategic REG investments reduced emissions. However, MPU enhanced environmental degradation. Pata et al. (2023a) reported that institutional quality could not affect renewable investments in G7 countries due to MPU. Zhang & Razzaq (2022) investigated the BRICST (Brazil, Russia, India, China, South Africa, and Turkey) economies and MPU suppressed the RET. However, the environmental effects of FD and environmental regulations were pleasant. In comparison, environmental regulations played the most significant role among others. Khan & Su (2022) investigated the G7 and found that MPU reduced REG investments across all quantiles. Particularly, this effect was found to be highest in the US and Italy. Zeng & Yue (2022) analyzed BRICS and reported that MPU depressed REC and increased non-REC. Zhou et al. (2022) explored China, India, and the US and found that REC mitigated emissions while MPU raised them.

Khan et al. (2022) investigated East Asia and reported that MPU raised CO_2 emissions. However, REC and FDI inflows reduced emissions. Chu & Le (2022) explored the G7 and found that MPU raised the negative effects of energy intensity. Moreover, MPU reduced the positive effects of REC and economic complexity. Xue et al. (2022) investigated France and confirmed that MPU increased emissions and reduced the benefits of clean energy policies. Iqbal et al. (2023) compared this relationship in developed and developing countries and showed that MPU increased CO_2 emissions in both cases. However, REC and urbanization improved environmental quality. In a methodological innovation, Syed & Bouri (2022) examined the US and reported that high MPU raised emissions. Saadaoui et al. (2023) also investigated the US and found that aggregate demand shocks increased emissions under MPU. However, a low MPU enabled oil supply or demand-specific shocks to reduce emissions.

Rong & Qamruzzaman (2022) investigated the top five oil-importing countries and found that MPU reduced the RET in the long run. However, technological innovation and oil price volatility moderated this relationship by promoting renewable energy growth. Jiao et al. (2022) and Qamruzzaman et al. (2022) discovered that MPU and GPR reduced the adoption of green technologies. However, FDI and government debt stimulated clean energy development, and MPU reduced these effects. Zhang et al. (2023c) investigated the REC-poverty-finance nexus in China and found that green finance reduced energy poverty through clean energy deployment. However, MPU reduced these gains by discouraging green investment. Serfraz et al. (2023) investigated Pakistan and found that both clean energy and FD attracted clean FDI. However, MPU reduced it. Jiang et al. (2023) investigated E7 countries and concluded that MPU reduced green growth. However, institutional quality and REC promoted green growth. Wang et al. (2023) identified that REC and urbanization were major emission-reducing factors. However, MPU, GPR, and economic growth raised environmental problems. Nakhli et al. (2022) did a causality analysis and found feedback between MPU and CO_2 emissions in the US. Economic uncertainty accelerated emissions, which also influenced policy dynamics in response. Wu et al. (2024) investigated the influence of MPU on loading capacity in fast-growing economies and confirmed that MPU deteriorated environmental quality in lower quantiles. However, REC improved environmental outcomes, and trade openness could not affect them. Khan et al. (2024) analyzed the BRICST nations from 1990 to 2020 and reported that REC improved ecological sustainability. However, GPR, MPU, and FD reduced ecological sustainability.

The literature also reported mixed effects of MPU on the environment. For instance, Pata (2024) reported time-variant results. While the short-run MPU enhanced the RET, the long-run MPU reduced sustainable investment. In another interesting finding, Saliba (2024) reported that energy-specific uncertainty supported the RET; however, global MPU reduced this effect. Li et al. (2023) found that Climate Policy Uncertainty (CPU) and MPU are context-dependent. They might sometimes encourage REC or hinder it. The net effect depended on the centrality of political commitment and adaptive governance in navigating energy transitions. Vitenu-Sackey & Acheampong (2022) found the heterogeneous impact of MPU across developed countries. These effects were found to be stronger in high-emission countries and weaker in low-emission countries. Udeagha & Muchapondwa (2022) investigated South Africa and revealed that MPU reduced the environmental benefits of REC and innovation. However, MPU surprisingly improved the environment with the interaction of complexity. Some studies could not find a significant environmental effect of MPU. Meng et al. (2024) and Naeem et al. (2024) investigated financially developed economies and discovered that FD and the RET significantly reduced ecological footprints, which could not be affected by MPU. Similarly, Appiah-Otoo (2021) could not validate the statistically significant effect of MPU on REC.

Table 2 and Figure 5 show the summary of the effects of MPU on the environment and energy sector. In this subsection, most literature concluded that MPU reduced the clean energy investment and environmental sustainability. However, the degree of impact was heterogeneous across regions and contexts, institutional capacity, technological innovations, FD, and other macroeconomic complexities. The studies emphasized promoting stable policy frameworks, regulatory clarity, and targeted incentives to accelerate the RET, which could mitigate environmental degradation under MPU. Innovation may be accelerated in some settings. However, MPU generally dampened investors' confidence and the RET in the long run. Moreover, institutional quality, FD, and policy predictability reduced the effect of MPU.

Table 2. Environmental effects of MPU and the energy sector

Environmental Effects of MPU	References	Regional Sample	Key Mechanisms
Positive	Adedoyin et al. (2021); Ahmed et al. (2021); Anser et al. (2021b); Anser et al. (2024); Ayad et al. (2023); Chen & Nouseen (2025); Dastgeer et al. (2023); Erzurumlu & Gozgor (2022); Fang et al. (2025); Selmey et al. (2024); Zhang et al. (2023a)	MENA, the US, Sub-Saharan Africa, the BRICST, the BRICS, and 72 countries	Renewable energy, FD, institutional capacity, green innovation, and economic complexity mitigated the negative environmental effects of MPU. The RET, REC, and FDI reduced emissions.
Negative	Adams et al. (2020); Chiou et al. (2025); Chu & Le (2022); Farouq & Sulong (2024); Iqbal et al. (2023); Ivanovski & Marinucci (2021); Jiang et al. (2023); Jiao et al. (2022); Kashif et al. (2025); Khan & Su (2022); Khan et al. (2022); Khan et al. (2024); Li et al. (2025); Nakhli et al. (2022); Oryani et al. (2022); Owusu et al. (2024); Pata et al. (2023a); Qamruzzaman et al. (2022); Rong & Qamruzzaman (2022); Saadaoui et al. (2023); Selmey & Elamer (2023); Serfraz et al. (2023); Shabir et al. (2022); Shafiullah et al. (2021); Syed & Bouri (2022); Wang et al. (2024a); Wang et al. (2023); Wei et al. (2023); Wu et al. (2024); Xu et al. (2024); Xue et al. (2022); Yi et al. (2023); You et al. (2023); Zeng & Yue (2022); Zhang & Razzaq (2022); Zhang et al. (2021); Zhang et al. (2023c); Zhou et al. (2022)	The US, E7, Arctic Council, the BRICS, the BRICST, South Korea, G7, Russia, G-10, the OPEC, China, Egypt, India, East Asia, developed countries, developing countries, and oil-importing countries	MPU reduced the progress of clean energy, the RET, REC, green technology adoption, and green investments. MPU raised emissions, ecological degradation, and fossil fuel use.
Mixed	Li et al. (2023); Pata (2024); Saliba (2024); Udeagha & Muchapondwa (2022); Vitenu-Sackey & Acheampong (2022)	South Africa and developed countries	MPU effects varied by region, governance, technology, economic fluctuations, and sectors.

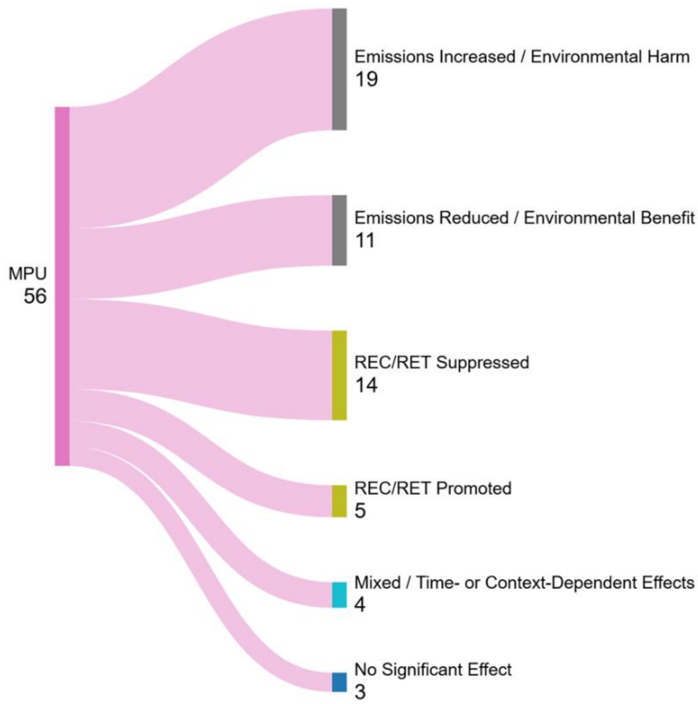

Figure 5. Role of MPU in the energy sector and environmental sustainability

3.3 MPU, Green Innovation, Technological Progress, and Environmental Sustainability

The sustainable technology development needs long-term stability and predictable policy frameworks, as it requires long-term investment. However, uncertainty-induced risk can reduce investment in green innovation and technological progress, thus forming a hurdle to environmental improvement. As regards the positive aspect of policy uncertainty, MPU can adopt adaptive strategies, which can be promoted by governments and firms to hedge against policy volatility. Thus, MPU may stimulate innovation, research and development (R&D) activities, and technological progress. However, the net effect of MPU depends on governance quality in an economy.

MPU might reduce the incentives for sustained investment in green technologies. For instance, Attílio (2025) empirically confirmed that MPU weakened green innovation. Moreover, GPR was the strongest inhibitor of green innovation. Deng et al. (2024) scrutinized the connection between MPU, technology, environment, and environmental taxation and concluded that MPU increased environmental degradation. Technology and environmental taxes significantly enhanced sustainability. Ali et al. (2023) analyzed the Organization for Economic Cooperation and Development (OECD) countries and found that MPU, FD, and energy use increased emissions. However, green innovation and institutional quality reduced them. Wei et al. (2022) investigated China and demonstrated that cities with lower technological development faced more energy efficiency losses during a high MPU. Yu et al. (2024) reinvestigated China and found that MPU interaction with green building intensity reduced the efficiency of carbon emissions.

Wang et al. (2021) explored 137 countries and confirmed that MPU increased carbon emissions. However, international cooperation and proactive national policy engagement could work as key strategies to mitigate the environmental costs of MPU. Shah et al. (2024) investigated East Asia and the Pacific and found that MPU increased emissions with rising AI adoption. Borojo et al. (2024) examined 25 emerging economies and revealed that MPU reduced green growth. However, technological innovations and good governance mediated this impact. Some studies reported the positive environmental effects of MPU, which was supported by technology. For instance, Borojo et al. (2024) discovered that innovations and governance quality promoted green growth. Moreover, the green growth indicator reduced the adverse effects of MPU. Ullah et al. (2022) studied the role of globalization in shaping the MPU-environment nexus and concluded that MPU reduced emissions in low and highly globalized economies.

A lot of studies reported the mixed or asymmetrical effects of MPU on the environment. Hussain et al. (2025) examined the BRICS countries and revealed that high MPU reduced emissions in Brazil and China, yet raised them in India and Russia. Thus, national energy infrastructure and development stages played their role in this nexus. Xin & Xin (2022) did a cross-country analysis and uncovered that MPU reduced pollution by limiting investment and economic activities. Further, MPU hindered innovations, which were responsible for long-term pollution. However, countries with R&D investment reversed this effect. In a methodological innovation, Zhang

& Xiao (2024) investigated the US and identified non-linear and asymmetric effects of MPU on ecological innovation and emissions. Similarly, Javed et al. (2023) scrutinized the asymmetric impact of MPU and green technology innovation on CO_2 emissions in Italy and found that positive shocks in green innovation helped reduce emissions. However, negative shocks in green innovation and MPU worsened environmental outcomes. Durani et al. (2023) and Zhang et al. (2023b) confirmed that the environmental benefits of technology were quantile-dependent and asymmetric. Thus, the importance of long-term green investment strategies was realized during MPU.

Table 3 and Figure 6 exhibit the summary of the environmental effects of MPU, including green innovation and technological progress in the analysis. This subsection highlighted that MPU reduced environmental sustainability by decreasing green innovation and technological advancement in times of high MPU. Thus, MPU discouraged investment in R & D and innovation, thus reducing technological progress and increasing environmental problems. However, these effects depend on R & D capacity, institutional quality, and policy framework in an economy.

Table 3. Environmental effects of MPU, including green innovation and technological progress in the model

Environmental Effects of MPU	References	Regional Sample	Key Mechanisms
Positive	Borojo et al. (2024); Ullah et al. (2022)	Global and cross-country	Positive shocks in green innovation reduced emissions. Technological innovations and good governance mitigated MPU effects. Institutional quality and globalization supported green growth and R&D investment.
Negative	Ali et al. (2023); Attílio (2025); Borojo et al. (2024); Deng et al. (2024); Shah et al. (2024); Wang et al. (2021); Wei et al. (2022); Yu et al. (2024)	Emerging economies, the US, Japan, China, the OECD, Global, and East Asia and the Pacific	MPU weakened green innovation and increased environmental degradation with lower energy efficiency.
Mixed	Hussain et al. (2025); Xin & Xin (2022)	Brazil, China, India, Russia, and the US	MPU effects varied by country, development stage, energy infrastructure, governance, and R&D investment levels.
Nonlinear	Durani et al. (2023); Javed et al. (2023); Zhang et al. (2023b); Zhang & Xiao (2024)	The US and Italy	MPU had asymmetric effects on the environment.

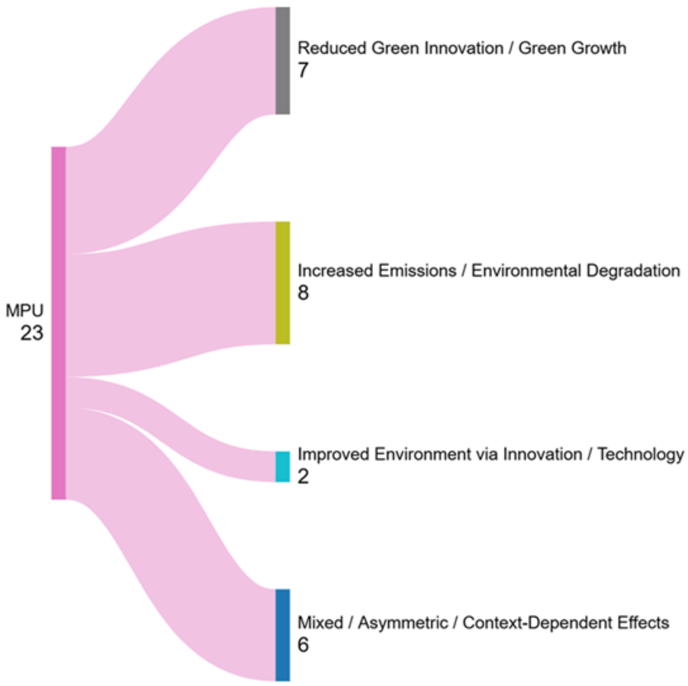

Figure 6. MPU, green innovation, technological progress, and environmental sustainability

3.4 Environmental Effects of MPU: The Role of Governance

Governance may serve as a moderating factor in the nexus between MPU and the environment. For instance, with weak institutions and governance, MPU can expedite environmental degradation by discouraging regulatory enforcement caused by corruption. On the other hand, strong governance can support regulatory quality, political stability, and corruption control, hence reducing the environmental problems of MPU. Strong governance could support adaptive policy reforms in times of MPU and would promote renewable adoption.

Table 4. Environmental effects of MPU and governance

Environmental Effects of MPU	References	Regional Sample	Key Mechanisms
Positive	Barra & Falcone (2024); Cui et al. (2024)	Global and the BRICS	Governance capacity, institutional quality, political stability, corruption control, and environmental policy reduced the negative effects of MPU on the environment.
Negative	Farooq et al. (2023); Hania et al. (2025); Hnainia & Mensi (2025); Khan et al. (2025); Ng et al. (2024); Sadiq et al. (2024); Zhang et al. (2024a); Zhang et al. (2024b)	GCC, Arctic region, the BRICS, Asia, 20 economies, and G7	MPU raised energy consumption, emissions, pollution, environmental harm, and damage of mental health.
Mixed	Assamoi & Wang (2023); Kilinc-Ata et al. (2025)	China and the US	MPU effects varied by divergent institutional and economic structures.

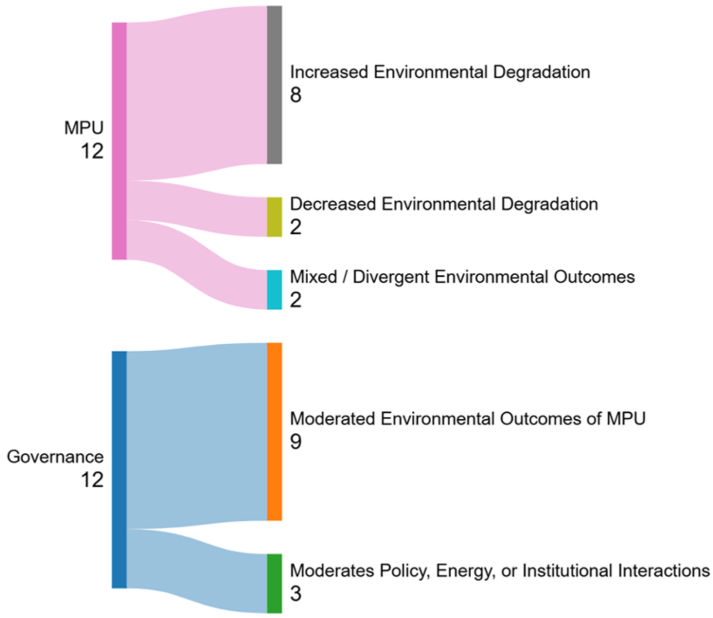

Figure 7. MPU, governance, and environmental sustainability

Barra & Falcone (2024) investigated 136 nations and confirmed that political orientation and governance capacity mitigated the environmental inefficiencies produced by MPU. Cui et al. (2024) examined the BRICS nations and concluded that the interaction of institutional quality with energy productivity reduced the negative environmental impact of MPU and GPR. Some studies reported the mixed effects of MPU. For instance, Assamoi & Wang (2023) analyzed China and the US and found that rising MPU degraded environmental quality. However, the interaction of MPU with environmental policy reduced these effects. Strong and consistent environmental regulations reduced the effects of MPU. Kilinc-Ata et al. (2025) recognized that high MPU raised short-run environmental benefits in China, and the US experienced a long-term deterioration effect. These results reflected divergent institutional and economic structures in both economies.

Most studies reported the adverse environmental effects of MPU. Hnainia & Mensi (2025) investigated the Gulf Cooperation Council (GCC) region and demonstrated that MPU raised energy consumption. However, strong governance, particularly regulatory quality and government effectiveness, reduced these effects. Sadiq et al. (2024) examined the BRICS countries and reported that MPU raised emissions. However, strong corruption control and the REC reduced these effects. The investigation of the BRICS countries conducted by Farooq et al. (2023) found that MPU increased CO_2 emissions. However, political stability moderated this relationship by reducing the environmental effects of MPU. Moreover, FD, FDI, and natural resource rents shaped the environmental implications of MPU. Khan et al. (2025) explored the Arctic region and reported that the interaction between urbanization and MPU exacerbated emissions. However, governance reduced these environmental damages.

Ng et al. (2024) assessed and reported that long-run MPU reduced environmental and social capital as it could be moderated by institutional development frameworks. Zhang et al. (2024b) identified feedback between MPU and pollution in 20 economies. Moreover, MPU had a strong effect on developing economies with high corruption, low trade openness, and high climate vulnerability. Hania et al. (2025) investigated G7 countries and found that MPU damaged public mental health and environmental sustainability. They suggested a holistic governance model to integrate mental health and environmental stability under MPU. Zhang et al. (2024a) proposed that MPU increased the environmental harm of mineral rent exploitation, which was due to resource governance under MPU.

Table 4 and Figure 7 incorporate governance indicators into the analysis and summarize the environmental effects of MPU. This subsection underscored that strong institutions and effective governance might act as a crucial channel to moderate the adverse environmental impacts of MPU. They could enhance resilience against geopolitical and economic shocks by enabling consistent policy enforcement, adaptive regulation, and strategic resource allocation. The effectiveness of governance in mitigating the negative environmental effects of MPU could be strengthened by promoting energy efficiency measures. The importance of institutional quality has been highlighted as a foundational element for sustainable environmental management under policy uncertainty.

3.5 Heterogeneous Environmental Effects of MPU and Context-Based Factors

The literature noted the heterogeneous environmental effects of MPU in different sectors. Thus, these effects significantly vary across sectors and regions, due to the degree of spatial and sectoral heterogeneity. The literature also reported a mixed or nonlinear effect of MPU on the environment.

Adebayo (2025) examined the US and found frequency- and sector-specific variations in the relationship between MPU and emissions. Ayhan et al. (2023) explored G7 countries and found substantial variation across countries and quantiles. For instance, MPU decreased emissions in Italy, Japan, and the US. However, it had adverse effects in Canada, Germany, France, and the UK. These effects were shaped by energy consumption at higher quantiles. In their examination of the OECD countries, Zahra & Badeeb (2022) revealed that green energy reduced ecological footprints. On the other hand, MPU reduced ecological footprints in the UK, USA, and Germany, and had insignificant effects in Australia and Canada. Thus, differential institutional and economic resilience shaped the effects of MPU. Borozan & Borozan (2022) found significant short-run MPU effects on energy in the G7. However, the long-run effects could not be validated.

MPU reduced CO_2 emissions in China at the aggregate level (Liu & Zhang, 2022), yet this effect was insignificant in central and western provinces as weaker institutional responses were observed in these less developed regions. Pata et al. (2023b) examined MPU and GPR across sectors during the Russia-Ukraine conflict and found that MPU reduced emissions in most sectors due to economic slowdowns. However, GPR was responsible for rising emissions in the transportation sector. Moreover, MPU-reduced emissions were more prominent compared to GPR in the electricity and transport sectors. In the nonlinear analysis, Ashena & Shahpari (2022) found the asymmetrical effects of MPU upon their investigation of Iran. For instance, positive shocks raised CO_2 emissions and negative shocks reduced them. Another research by Brini et al. (2024) on Africa reported that positive MPU shocks reduced environmental quality whereas negative shocks improved it. Short-run effects were found to be negligible. Some studies shed light on the positive environmental effects of MPU. For instance, Anser et al. (2021a) examined the world's top ten carbon emitters and reported that MPU reduced emissions. Yang et al. (2022) analyzed Chinese provinces and found that MPU reduced pollution by reducing consumption, and this effect was more prominent in economically developed regions.

As regards the negative environmental effects of MPU, Mohanty et al. (2025) investigated G20 economies to arrive at the result that MPU, nuclear energy, and the oil sector raised emissions. Agricultural growth reduced emissions under MPU while the industrial and service sectors raised the environmental effects of MPU. Yang et al. (2024) applied spatial analysis to 282 Chinese cities and found that MPU increased emissions intensity in local and neighboring regions through spillovers. Wen & Zhang (2022) reported that MPU elevated emissions in fiscally constrained Chinese cities with local governments' scale-back environmental enforcement. Thus, institutional fragility emerged under MPU at the subnational level. Ma et al. (2024) examined highly polluted nations and revealed that MPU raised ecological footprints. Li et al. (2024) scrutinized the BRICS and found that MPU and non-REC increased ecological footprints. However, GPR and REC mitigated them. Arshad et al. (2024) investigated the moderating effect of financial inclusion and found that this mitigated the negative environmental impact of MPU. The study of Qamruzzaman (2023) on India and China noted the use of remittances as a moderator. MPU reduced environmental quality. Remittances proxy for external economic shocks moderated the environmental effects of MPU. Odugbesan & Aghazadeh (2021) applied multiple proxies of MPU, including fiscal, monetary, exchange rate, and trade policy shocks, which increased pollution in Japan. Anwar et al. (2024) reported that REC and FD reduced the harmful effects of MPU and technological shocks in the "Fragile Five" countries, i.e., Turkey, Brazil, India, South Africa, and Indonesia. Shah & Zha (2025) examined the BRICS countries and demonstrated that MPU and stringency of environmental policy raised the energy rebound effect.

Table 5 and Figure 8 illustrate the heterogeneous environmental effects of the MPU. This subsection exposed that the environmental effects of MPU were highly heterogeneous, depending on sectoral features, regional conditionality, and asymmetric policy responses. The literature signified that a single strategy was not sufficient to mitigate the environmental effects of MPU, which could be tackled by context-specific, flexible, and sector-aware environmental governance. Therefore, tailored strategies taking into account of local institutional capacity, economic structure, and development level can effectively mitigate the negative environmental effects caused by MPU.

Table 5. Environmental effects of the MPU, including various proxies in different models

Environmental Effects of MPU	References	Regional Sample	Key Mechanisms
Positive	Anser et al. (2021a); Yang et al. (2022)	G7 and Chinese provinces	MPU reduced emissions in some sectors and countries due to economic slowdowns, energy mix, institutional resilience, and reduction in energy consumption.
Negative	Anwar et al. (2024); Li et al. (2024); Ma et al. (2024); Mohanty et al. (2025); Odugbesan & Aghazadeh (2021); Qamruzzaman (2023); Shah & Zha (2025); Wen & Zhang (2022); Yang et al. (2024)	G20, Chinese cities, highly polluted nations, the BRICS, India, China, and Japan	MPU raised emissions and ecological footprints due to sectoral, spatial, fiscal constraints, and policy stringency.
Mixed	Adebayo (2025); Ayhan et al. (2023); Borozan & Borozan (2022); Liu & Zhang (2022); Pata et al. (2023b); Zahra & Badeeb (2022)	G7, the OECD, China, and the US	MPU effects varied by country, shocks (positive/negative), and time frame (short vs. long run).
Nonlinear	Ashena & Shahpari (2022); Brini et al. (2024)	Africa and Iran	MPU impacts showed asymmetrical effects on emissions.

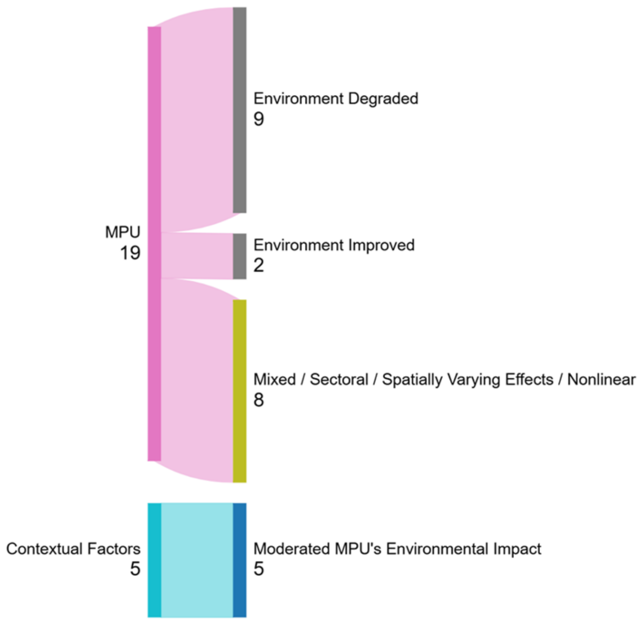

Figure 8. MPU, context-based factors, and environmental sustainability

4. Synthesis of the Literature

The literature signified the role of MPU in the EKC framework. For instance, MPU can delay the first phase of the EKC by discouraging investments in cleaner technologies and renewable energy. Thus, MPU can be responsible for the invalidity of the EKC hypothesis. Moreover, MPU may reduce the speed of structural transformation in an economy, hence delaying the transition of an economy from the first to the second phase of the EKC. On the other hand, reducing MPU can ensure stable policy regimes, which can accelerate the transition of an economy from the first to the second phase of the EKC by promoting the RET, environmental regulations, and technological innovation.

Recent literature has explored the relationship between MPU and the environment by using different proxies. The broad conclusion of the literature review signified that MPU could not affect the environment uniformly across different countries, regions, sectors, and time horizons. Its effect was conditioned by spatial interdependence, sectoral compositions, policy frameworks, and context-specific analyses. At the sectoral level, the literature signified that MPU affected differently in terms of energy consumption patterns and industrial structures. For instance, MPU reduced emissions in the agriculture and renewable energy sectors during MPU. However, the results were found to be opposite in industry and services. These different sectoral results exposed that MPU improved the environment due to investment delays, shifts in energy mix, and changes in regulatory prosecution.

The methodological approach provided multifaceted results from analyses of quantile regression approaches, the asymmetric approach, and the nonlinear effects of MPU. In the asymmetric approach, positive and negative shocks of MPU showed different environmental effects. For example, emissions declined with positive MPU shocks in certain countries due to reduced industrial output. However, emissions were increased due to weak environmental forecasting. The magnitude and direction of these effects often differed in different quantiles of emission distributions, which reflect a different prevailing environmental state and policy stringency in any economy. In the spatial analyses, significant spillovers of MPU were found. MPU in one county might raise environmental risks in neighboring areas, and integrated supply chains and common ecosystems are responsible for it. Therefore, spatial econometric models showed that local and regional policy coordination was essential to manage these spillovers. Institutional quality, environmental regulations, and fiscal pressures also moderated the MPU-environment relationship.

The temporal dimension also plays a critical role. For instance, the short-run effects of MPU are often characterized by economic slowdowns and reduced emissions. In the long run, MPU postpones green investments and regulatory rollback, which increase ecological footprints. Moreover, the interaction effects of MPU with GPR, volatility of oil price, stringency of environmental policy, and financial inclusion are further responsible for the different results. For instance, MPU can either increase or mitigate environmental harms, depending on the policy environment, resource endowments, and structural resilience of the economy. The positive environmental effects of REC, institutional quality, and innovations help to raise the possibility of the positive environmental effects of MPU.

5. Conclusions

MPU has great potential to determine the environmental quality in any economy, and the recent literature has extensively explored this relationship with mixed findings. This research aims to review this relationship by following a systematic review approach, which helped select 117 articles. The findings of the study exposed the complex, context-dependent, and nonlinear relationship between MPU and environmental sustainability. MPU affected the environment through different channels, including economic slowdowns, investment delays, regulatory loops, and behavioral reactions. The results were found to be different across different sectors, regions, and time horizons. For instance, MPU reduced emissions in the agriculture sector due to a reduction in economic activities and increased emissions in energy-intensive and industrial sectors. Spatial analyses showed the spillover effect of MPU on the environment due to interregional economic linkages and institutional heterogeneities, which highlighted the need for coordinated political actions at local, national, and regional levels. Moreover, the relationship was found to be asymmetrical, indicating that policy responses differed in accordance with the asymmetrical results. MPU has a dynamic relationship with GPR, energy policy, fiscal response, and environmental policy.

The findings of this review suggested that MPU was responsible for delaying long-term investment in green projects. In the policy debate, strengthening institutional frameworks like improving the rule of law, transparency, and accountability can provide predictability in policy environments, hence reducing the volatility faced by investors and promoting long-term investment in projects of renewable energy and technologies. Furthermore, well-informed and consistent fiscal and monetary policies may reduce the volatility of MPU and minimize the disruptive impact of MPU on the environment in an economy. Moreover, the findings implied that governments should design flexible environmental policies to be matched with both positive and negative shocks in MPU. Additionally, environmental regulations and their concomitant regional coordination may reduce the environmental effects of MPU. The promotion of financial inclusion, REG investment, and technological innovation could also provide solutions to improve environmental performance under MPU. Given the sector-specific effects of MPU, policymakers should design sector-specific policies. For instance, subsidies should be provided for the RET, and taxes should be imposed on fossil fuel energy, transportation, and industrial sectors. Policymakers should consider the environmental spillovers of MPU while designing cross-border environmental agreements and regional emission caps. The government should promote inclusive finance, which could support green investments and REC adoption. R&D should be promoted to reduce the environmental effects of MPU. Moreover, MPU should be combined with other uncertainties, like GPR and oil price shocks, to establish a comprehensive environmental sustainability framework.

The analysis of sectoral heterogeneity of MPU environmental effect is scant in the present MPU literature. Future research should therefore explore this aspect further. Investigating the complementarity of MPU with other uncertainties like GPR and oil price shocks would extend the scope of the MPU literature. Furthermore, employing mixed-method approaches in combination with spatial and non-spatial analyses would allow comparison of the results. The robustness of the findings could be enhanced by including spatial spillovers of MPU on the environment of neighboring countries or regions in the analysis.

Author Contributions

Conceptualization, H.M.; methodology, H.M.; software, H.M.; validation, H.M. and A.U.R.I.; formal analysis, H.M.; investigation, H.M.; resources, H.M.; data curation, H.M.; writing—original draft preparation, H.M. and A.U.R.I.; writing—review and editing, H.M. and A.U.R.I.; visualization, H.M. and A.U.R.I.; supervision, H.M.; project administration, H.M.; funding acquisition, H.M. All authors have read and agreed to the published version of the manuscript.

Funding

The authors extend their appreciation to Prince Sattam bin Abdulaziz University for funding this research work (Project No.: PSAU/2025/02/32829).

Data Availability

The data used to support the research findings are available from the corresponding author upon request.

Conflicts of Interest

The authors declare no conflicts of interest.

References

Adams, S., Adedoyin, F., Olaniran, E., & Bekun, F. V. (2020). Energy consumption, economic policy uncertainty and carbon emissions; causality evidence from resource rich economies. *Econ. Anal. Policy*, *68*, 179–190. https://doi.org/10.1016/j.eap.2020.09.012.

Adebayo, T. S. (2025). Response of sectoral CO_2 emissions to climate and economic policy uncertainties: A multi-frequency quantile analysis. *Appl. Econ.*, 1–20. https://doi.org/10.1080/00036846.2025.2490857.

Adedoyin, F. F., Ozturk, I., Agboola, M. O., Agboola, P. O., & Bekun, F. V. (2021). The implications of renewable and non-renewable energy generating in Sub-Saharan Africa: The role of economic policy uncertainties. *Energy Policy*, *150*, 112115. https://doi.org/10.1016/j.enpol.2020.112115.

Ahmed, Z., Cary, M., Shahbaz, M., & Vo, X. V. (2021). Asymmetric nexus between economic policy uncertainty, renewable energy technology budgets, and environmental sustainability: Evidence from the United States. *J. Clean. Prod.*, *313*, 127723. https://doi.org/10.1016/j.jclepro.2021.127723.

Ali, K., Du, J., Kirikkaleli, D., Oláh, J., & Altuntaş, M. (2023). Do green technological innovation, financial development, economic policy uncertainty, and institutional quality matter for environmental sustainability? *All Earth*, *35*(1), 82–101. https://doi.org/10.1080/27669645.2023.2200330.

Ali, S., Jiang, J., Ahmad, M., Usman, O., & Ahmed, Z. (2022). A path towards carbon mitigation amidst economic policy uncertainty in BRICS: An advanced panel analysis. *Environ. Sci. Pollut. Res.*, *29*(41), 62579–62591. https://doi.org/10.1007/s11356-022-20004-8.

Anser, M. K., Apergis, N., & Syed, Q. R. (2021a). Impact of economic policy uncertainty on CO_2 emissions: Evidence from top ten carbon emitter countries. *Environ. Sci. Pollut. Res.*, *28*(23), 29369–29378. https://doi.org/10.1007/s11356-021-12782-4.

Anser, M. K., Ogede, J. S., Huizhen, W., Aderemi, T. A., Ali, S., & Osabohien, R. (2024). Analysing the impacts of shadow economy, financial inclusion and economic policy uncertainty on CO_2 emissions. *Politicka Ekon.*, *72*(6), 867–895. https://10.18267/j.polek.1435.

Anser, M. K., Syed, Q. R., Lean, H. H., Alola, A. A., & Ahmad, M. (2021b). Do economic policy uncertainty and geopolitical risk lead to environmental degradation? Evidence from emerging economies. *Sustainability*, *13*(11), 5866. https://doi.org/10.3390/su13115866.

Anwar, A., Barut, A., Pala, F., Kilinc-Ata, N., Kaya, E., & Lien, D. T. Q. (2024). A different look at the environmental Kuznets curve from the perspective of environmental deterioration and economic policy uncertainty: Evidence from fragile countries. *Environ. Sci. Pollut. Res.*, *31*(34), 46235–46254. https://doi.org/10.1007/s11356-023-28761-w.

Appiah-Otoo, I. (2021). Impact of economic policy uncertainty on renewable energy growth. *Energy Res. Lett.*, *2*(1). https://doi.org/10.46557/001c.19444.

Arshad, A., Gulzar, O., Shahid, O. B., & Nawaz, F. (2024). Exploring the mediating role of financial inclusion in the relationship between economic policy uncertainty and CO_2 emissions: A global perspective. *Environ. Sci. Pollut. Res.*, *31*(34), 46965-46978. https://doi.org/10.1007/s11356-024-33954-y.

Ashena, M. & Shahpari, G. (2022). Policy uncertainty, economic activity, and carbon emissions: A nonlinear autoregressive distributed lag approach. *Environ. Sci. Pollut. Res.*, *29*(34), 52233–52247. https://doi.org/10.1007/s11356-022-19432-3.

Aslan, A., Ilhan, O., Usama, A. M., Savranlar, B., Polat, M. A., Metawa, N., & Raboshuk, A. (2024). Effect of economic policy uncertainty on CO_2 with the discrimination of renewable and non renewable energy consumption. *Energy*, *291*, 130382. https://doi.org/10.1016/j.energy.2024.130382.

Assamoi, G. R. & Wang, S. (2023). Asymmetric effects of economic policy uncertainty and environmental policy stringency on environmental quality: Evidence from China and the United States. *Environ. Sci. Pollut. Res.*, *30*(11), 29996-30016. https://doi.org/10.1007/s11356-022-24082-6.

Attílio, L. A. (2025). Spillover effects of climate policy uncertainty on green innovation. *J. Environ. Manage.*, *375*, 124334. https://doi.org/10.1016/j.jenvman.2025.124334.

Ayad, H., Sari-Hassoun, S. E., Usman, M., & Ahmad, P. (2023). The impact of economic uncertainty, economic growth and energy consumption on environmental degradation in MENA countries: Fresh insights from multiple thresholds NARDL approach. *Environ. Sci. Pollut. Res.*, *30*(1), 1806–1824. https://doi.org/10.1007/s11356-022-22256-w.

Ayhan, F., Kartal, M. T., Kılıç Depren, S., & Depren, Ö. (2023). Asymmetric effect of economic policy uncertainty, political stability, energy consumption, and economic growth on CO_2 emissions: Evidence from G-7 countries. *Environ. Sci. Pollut. Res.*, *30*(16), 47422–47437. https://doi.org/10.1007/s11356-023-25665-7.

Balsalobre-Lorente, D., Nur, T., Topaloglu, E. E., & Evcimen, C. (2024). The dampening effect of geopolitical risk and economic policy uncertainty in the linkage between economic complexity and environmental degradation in the G-20. *J. Environ. Manage.*, *351*, 119679. https://doi.org/10.1016/j.jenvman.2023.119679.

Barra, C. & Falcone, P. M. (2024). Unraveling the impact of economic policy uncertainty on environmental efficiency: How do institutional quality and political orientation matter? *Econ. Politics*, *36*(3), 1450–1490. https://doi.org/10.1111/ecpo.12297.

Barra, C., Falcone, P. M., & Giganti, P. (2025). Exploring the impact of economic, climate, and energy policy uncertainty on the Environmental Kuznets Curve: International evidence. *Int. Econ.*, *182*, 100592. https://doi.org/10.1016/j.inteco.2025.100592.

Borojo, D. G., Yushi, J., Miao, M., & Xiao, L. (2024). The impacts of economic policy uncertainty, energy consumption, sustainable innovation, and quality of governance on green growth in emerging economies. *Energy Environ.*, *35*(7), 3647–3672. https://doi.org/10.1177/0958305X231173997.

Borozan, D. & Borozan, B. (2022). The asymmetric effect of economic policy uncertainty on energy consumption. *Energy Effic.*, *15*(5), 28. https://doi.org/10.1007/s12053-022-10037-w.

Brini, R., Toumi, H., Chaouech, O., Toumi, S., & Alfalih, A. A. (2024). Unveiling asymmetry impacts of economic policy uncertainty on climate change: Fresh insights into African Countries. *Environ. Sci. Pollut. Res.*, *31*(23), 34647–34660. https://doi.org/10.1007/s11356-024-33516-2.

Chen, S. & Nouseen, S. (2025). Tackling economic policy uncertainty and improving energy security through clean energy change. *Energy*, *315*, 134356. https://doi.org/10.1016/j.energy.2024.134356.

Chiou, W. J. P., Fu, S. H., Lin, J. B., & Tsai, W. (2025). Exploring the impacts of economic policies, policy uncertainty, and politics on carbon emissions. *Environ. Resour. Econ.*, *88*(4), 895–919. https://doi.org/10.1007/s10640-025-00954-6.

Chu, L. K., Doğan, B., Abakah, E. J. A., Ghosh, S., & Albeni, M. (2023). Impact of economic policy uncertainty, geopolitical risk, and economic complexity on carbon emissions and ecological footprint: An investigation of the E7 countries. *Environ. Sci. Pollut. Res.*, *30*(12), 34406–34427. https://doi.org/10.1007/s11356-022-24682-2.

Chu, L. K. & Le, N. T. M. (2022). Environmental quality and the role of economic policy uncertainty, economic complexity, renewable energy, and energy intensity: The case of G7 countries. *Environ. Sci. Pollut. Res.*, *29*(2), 2866–2882. https://doi.org/10.1007/s11356-021-15666-9.

Cui, X., Wang, W., Işık, C., Uddin, I., Yan, J., Gu, X., & Ahmad, M. (2024). Do geopolitical risk and economic policy uncertainty cause CO_2 emissions in BRICS? The role of institutional quality and energy productivity. *Stoch. Environ. Res. Risk Assess.*, *38*(5), 1685–1699. https://doi.org/10.1007/s00477-023-02646-3.

Cutcu, I., Altiner, A., & Bozkurt, E. (2025). The impact of economic policy uncertainty and geopolitical risk on

environmental quality: An analysis of the environmental Kuznets curve hypothesis with the novel QRPD approach. *Sustainability*, *17*(1), 269. https://doi.org/10.3390/su17010269.
Dastgeer, A., Shabir, M., Usman, M., Kamal, M., Khan, & M. F. (2023). Environmental cost of natural resources, globalization, and economic policy uncertainty in the G-7 bloc: Do human capital and renewable energy matter? *Environ. Sci. Pollut. Res.*, *30*(54), 115081–115097. https://doi.org/10.1007/s11356-023-30485-w.
Deng, X., Qamruzzaman, M., & Karim, S. (2024). Unlocking the path to environmental sustainability: Navigating economic policy uncertainty, ICT, and environmental taxes for a sustainable future. *Environ. Sci. Pollut. Res.*, *31*(25), 37136-37162. https://doi.org/10.1007/s11356-024-33566-6.
Durani, F., Bhowmik, R., Sharif, A., Anwar, A., & Syed, Q. R. (2023). Role of economic uncertainty, financial development, natural resources, technology, and renewable energy in the environmental Phillips curve framework. *J. Clean. Prod.*, *420*, 138334. https://doi.org/10.1016/j.jclepro.2023.138334.
Erzurumlu, Y. O. & Gozgor, G. (2022). Effects of economic policy uncertainty on energy demand: Evidence from 72 countries. *J. Chin. Econ. Bus. Stud.*, *20*(1), 23–38. https://doi.org/10.1080/14765284.2021.2009999.
Fang, Y., Lee, C. C., & Li, X. (2025). Assessing the impact of artificial intelligence on the transition to renewable energy? Analysis of US states under policy uncertainty. *Renew. Energy*, *246*, 122969. https://doi.org/10.1016/j.renene.2025.122969.
Farooq, U., Gillani, S., Subhani, B. H., & Shafiq, M. N. (2023). Economic policy uncertainty and environmental degradation: The moderating role of political stability. *Environ. Sci. Pollut. Res.*, *30*(7), 18785–18797. https://doi.org/10.1007/s11356-022-23479-7.
Farouq, I. S. & Sulong, Z., (2024). Economic policy uncertainty and renewable energy consumption: Evidence from oil-rich countries. *J. Sustain. Sci. Manag.*, *19*(2), 150–172. http://doi.org/10.46754/jssm.2024.02.008.
Hania, A., Lee, C. C., & Yahya, F. (2025). Climate anxiety, economic policy uncertainty, and green growth. *Econ. Chang. Restruct.*, *58*(1), 14. https://doi.org/10.1007/s10644-025-09854-7.
Haq, I. U., Maneengam, A., Chupradit, S., Suksatan, W., & Huo, C. (2021). Economic policy uncertainty and cryptocurrency market as a risk management avenue: A systematic review. *Risks*, *9*(9), 163. https://doi.org/10.3390/risks9090163.
Hassan, S. T., Batool, B., Sadiq, M., & Zhu, B. (2022). How do green energy investment, economic policy uncertainty, and natural resources affect greenhouse gas emissions? A Markov-switching equilibrium approach. *Environ. Impact Assess. Rev.*, *97*, 106887. https://doi.org/10.1016/j.eiar.2022.106887.
Hnainia, H. & Mensi, S. (2025). The role of institutional factors in shaping the relationship between economic policy uncertainty and energy consumption in Gulf countries: An empirical analysis. *J. Financ. Econ. Policy*, *17*(2), 246–269. https://doi.org/10.1108/JFEP-02-2024-0049.
Hussain, I., Saqib, A., & Lean, H. H. (2025). Economic policy uncertainty and green energy in BRICS: Impacts on sustainability. *Energy*, *317*, 134717. https://doi.org/10.1016/j.energy.2025.134717.
Iqbal, M., Chand, S., & Ul Haq, Z. (2023). Economic policy uncertainty and CO_2 emissions: A comparative analysis of developed and developing nations. *Environ. Sci. Pollut. Res.*, *30*(6), 15034–15043. https://doi.org/10.1007/s11356-022-23115-4.
Işık, C., Simionescu, M., Ongan, S., Radulescu, M., Yousaf, Z., Rehman, A., & Ahmad, M. (2023). Renewable energy, economic freedom and economic policy uncertainty: New evidence from a dynamic panel threshold analysis for the G-7 and BRIC countries. *Stoch. Environ. Res. Risk Assess.*, *37*(9), 3367–3382. https://doi.org/10.1007/s00477-023-02452-x.
Ivanovski, K. & Marinucci, N. (2021). Policy uncertainty and renewable energy: Exploring the implications for global energy transitions, energy security, and environmental risk management. *Energy Res. Soc. Sci.*, *82*, 102415. https://doi.org/10.1016/j.erss.2021.102415.
Javed, A., Fuinhas, J. A., & Rapposelli, A. (2023). Asymmetric nexus between green technology innovations, economic policy uncertainty, and environmental sustainability: Evidence from Italy. *Energies*, *16*(8), 3557. https://doi.org/10.3390/en16083557.
Jiang, Y., Sharif, A., Anwar, A., Cong, P. T., Lelchumanan, B., Yen, V. T., & Vinh, N. T. T. (2023). Does green growth in E-7 countries depend on economic policy uncertainty, institutional quality, and renewable energy? Evidence from quantile-based regression. *Geosci. Front.*, *14*(6), 101652. https://doi.org/10.1016/j.gsf.2023.101652.
Jiao, Y., Xiao, X., & Bao, X. (2022). Economic policy uncertainty, geopolitical risks, energy output and ecological footprint—Empirical evidence from China. *Energy Rep.*, *8*, 324–334. https://doi.org/10.1016/j.egyr.2022.03.105.
Kashif, U., Abbas, S., Kousar, S., & Lu, H. (2025). Linking of bio-energy and carbon neutrality: Navigating economic policy uncertainty and climate change policy in the USA. *Energy*, *324*, 136012. https://doi.org/10.1016/j.energy.2025.136012.
Khan, K. A., Cong, P. T., Abbas, A., Ahmad, P., Quynh, N. N., Nguyen, M. Q., & Anwar, A. (2024). Navigating the environmental impact of geopolitical risk and economic policy uncertainty: Evidence from load capacity curve hypothesis in BRICST economies. *Nat. Resour. Forum*, *49*(4), 3511–3530.

https://doi.org/10.1111/1477-8947.12538.
Khan, K. & Su, C. W. (2022). Does policy uncertainty threaten renewable energy? Evidence from G7 countries. *Environ. Sci. Pollut. Res.*, *29*(23), 34813–34829. https://doi.org/10.1007/s11356-021-16713-1
Khan, M., Hassan, H., Li, C., Sampene, A. K., & Kyere, F. (2025). Achieving carbon neutrality through renewable energy transition amidst economic policy uncertainty in the Arctic region. *Int. J. Energy Res.*, *2025*(1), 2408883. https://doi.org/10.1155/er/2408883.
Khan, Y., Hassan, T., Kirikkaleli, D., Xiuqin, Z., & Shukai, C. (2022). The impact of economic policy uncertainty on carbon emissions: Evaluating the role of foreign capital investment and renewable energy in East Asian economies. *Environ. Sci. Pollut. Res.*, *29*(13), 18527–18545. https://doi.org/10.1007/s11356-021-17000-9.
Kilinc-Ata, N., Camkaya, S., Akca, M., & Topal, S. (2025). The impact of uncertainty in economic policy on the load capacity factors in China and the United States (US): New evidence from novel Fourier bootstrap ARDL approach. *J. Sustain. Res.*, *7*(1). https://doi.org/10.20900/jsr20250002.
Li, C., Sampene, A. K., Wiredu, J., & Nsiah, T. K. (2025). Economic policy uncertainty and renewable energy transition: Assessing the impact of resource richness, environmental technology, and environmental governance. *Renew. Energy*, *244*, 122670. https://doi.org/10.1016/j.renene.2025.122670.
Li, H., Ali, M. S. E., Ayub, B., & Ullah, I. (2024). Analysing the impact of geopolitical risk and economic policy uncertainty on the environmental sustainability: Evidence from BRICS countries. *Environ. Sci. Pollut. Res.*, *31*(34), 46148–46162. https://doi.org/10.1007/s11356-023-26553-w.
Li, Z. Z., Su, C. W., Moldovan, N. C., & Umar, M. (2023). Energy consumption within policy uncertainty: Considering the climate and economic factors. *Renew. Energy*, *208*, 567–576. https://doi.org/10.1016/j.renene.2023.03.098.
Liberati, A., Altman, D., Tetzlaff, J., Mulrow, C., Gøtzsche, P., Ioannidis, J., Clarke, M., Devereaux, P. J., Kleijnen, J., & Moher, D. (2009). The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: Explanation and elaboration. *J. Clin. Epidemiol.*, 62(10), e1–e34. https://doi.org/10.1016/j.jclinepi.2009.06.006.
Liu, Y. & Zhang, Z. (2022). How does economic policy uncertainty affect CO_2 emissions? A regional analysis in China. *Environ. Sci. Pollut. Res.*, *29*(3), 4276–4290. https://doi.org/10.1007/s11356-021-15936-6.
Ma, J., Zhang, J., Ali, S., Nazar, R., & Anser, M. K. (2024). Strategic socioeconomic planning to address ecological footprints in an uncertain economic landscape. *Socio-Econ. Plan. Sci.*, *95*, 102048. https://doi.org/10.1016/j.seps.2024.102048.
Meng, K., Khan, M. N., Adebayo, T. S., & Olanrewaju, V. O. (2024). How do oil price uncertainty and economic policy uncertainty influence achievement of net-zero emissions targets by 2050? A quantile-based analysis. *Int. J. Sustain. Dev. World Ecol.*, *31*(7), 892–911. https://doi.org/10.1080/13504509.2024.2344860.
Mohanty, S., Dash, S., Priyadarshini, S., Dulla, N., & Swain, S. C. (2025). Does economic policy uncertainty, nuclear energy, and crude oil influence CO_2 emissions? A sectoral growth analysis on G20 countries. *Environ. Sci. Pollut. Res.*, *32*(1), 117–133. https://doi.org/10.1007/s11356-024-35603-w.
Mushtaq, M., Hameed, G., Ahmed, S., Fahlevi, M., Aljuaid, & M., Saniuk, S. (2024). How does economic policy uncertainty impact CO_2 emissions? Investigating investment's role across 22 economies (1997–2021). *Energy Rep.*, *11*, 5083–5091. https://doi.org/10.1016/j.egyr.2024.04.069.
Naeem, F., Deng, Y., & Naveed, M. (2024). The triple helix of environmental prosperity: Economic policy uncertainty, financial expansion, and green energy in a financially flourishing bloc. *Nat. Resour. Forum*, *49*(4), 3911–3933. https://doi.org/10.1111/1477-8947.12542.
Nakhli, M. S., Shahbaz, M., Jebli, M. B., & Wang, S. (2022). Nexus between economic policy uncertainty, renewable & non-renewable energy and carbon emissions: Contextual evidence in carbon neutrality dream of USA. *Renew. Energy*, *185*, 75–85. https://doi.org/10.1016/j.renene.2021.12.046.
Ng, T. H., Lim, Y. S., Lim, Y. Z., Chan, K. H., & Lye, C. T. (2024). Is economic policy uncertainty detrimental to sustainability? Evidence from Asian countries. *Environ. Dev. Sustain.*, *26*(8), 20885–20908. https://doi.org/10.1007/s10668-023-03510-8.
Odugbesan, J. A. & Aghazadeh, S. (2021). Environmental pollution and disaggregated economic policy uncertainty: Evidence from Japan. *Pollution*, *7*(4), 749–767. https://doi.org/10.22059/poll.2021.321490.1057.
Oryani, B., Moridian, A., Rezania, S., Vasseghian, Y., Bagheri, M., & Shahzad, K. (2022). Asymmetric impacts of economic uncertainties and energy consumption on the ecological footprint: Implications apropos structural transformation in South Korea. *Fuel*, *322*, 124180. https://doi.org/10.1016/j.fuel.2022.124180.
Owusu, S. M., Chuanbo, F., & Qiao, H. (2024). Examining economic policy uncertainty's impact on environmental sustainability: Insights from nordic nations. *J. Clean. Prod.*, *449*, 141688. https://doi.org/10.1016/j.jclepro.2024.141688.
Pata, S. K. (2024). Comparative impacts of energy, climate, and economic policy uncertainties on renewable energy. *J. Environ. Manage.*, *370*, 122494. https://doi.org/10.1016/j.jenvman.2024.122494.
Pata, U. K., Alola, A. A., Erdogan, S., & Kartal, M. T. (2023a). The influence of income, economic policy uncertainty, geopolitical risk, and urbanization on renewable energy investments in G7 countries. *Energy*

Econ., *128*, 107172. https://doi.org/10.1016/j.eneco.2023.107172.
Pata, U. K., Kartal, M. T., & Zafar, M. W. (2023b). Environmental reverberations of geopolitical risk and economic policy uncertainty resulting from the Russia-Ukraine conflict: A wavelet based approach for sectoral CO_2 emissions. *Environ. Res.*, *231*, 116034. https://doi.org/10.1016/j.envres.2023.116034.
Qamruzzaman, M. (2023). Does environmental degradation-led remittances flow? Nexus between environmental degradation, uncertainty, financial inclusion and remittances inflows in India and China. *Int. J. Energy Econ. Policy, 13*(2), 9–26. https://doi.org/10.32479/ijeep.13995.
Qamruzzaman, M., Karim, S., & Jahan, I. (2022). Nexus between economic policy uncertainty, foreign direct investment, government debt and renewable energy consumption in 13 top oil importing nations: Evidence from the symmetric and asymmetric investigation. *Renew. Energy*, *195*, 121–136. https://doi.org/10.1016/j.renene.2022.05.168.
Rong, G. & Qamruzzaman, M. (2022). Symmetric and asymmetric nexus between economic policy uncertainty, oil price, and renewable energy consumption in the United States, China, India, Japan, and South Korea: Does technological innovation influence? *Front. Energy Res.*, *10*, 973557. https://doi.org/10.3389/fenrg.2022.973557.
Saadaoui, Z., Boufateh, T., & Jiao, Z. (2023). On the transmission of oil supply and demand shocks to CO_2 emissions in the US by considering uncertainty: A time-varying perspective. *Resour. Policy*, *85*, 104031. https://doi.org/10.1016/j.resourpol.2023.104031.
Sadiq, M., Hassan, S. T., Khan, I., & Rahman, M. M. (2024). Policy uncertainty, renewable energy, corruption and CO_2 emissions nexus in BRICS-1 countries: A panel CS-ARDL approach. *Environ. Dev. Sustain.*, *26*(8), 21595–2162. https://doi.org/10.1007/s10668-023-03546-w.
Saliba, C. (2024). Do the energy-related uncertainties stimulate renewable energy demand in developed economies? Fresh evidence from the role of environmental policy stringency and global economic policy uncertainty. *Energies*, *17*(18), 4746. https://doi.org/10.3390/en17184746.
Selmey, M. G., & Elamer, A. A. (2023). Economic policy uncertainty, renewable energy and environmental degradation: Evidence from Egypt. *Environ. Sci. Pollut. Res.*, *30*(20), 58603–58617. https://doi.org/10.1007/s11356-023-26426-2.
Selmey, M. G. S. G., Elkhodary, Y. F. Y., & Elsayed, E. F. E. M. (2024). Economic policy uncertainty, energy consumption, trade openness and CO_2 emissions: Evidence from BRICS countries. *Int. J. Energy Econ. Policy*, *14*(6), 554–565. https://doi.org/10.32479/ijeep.16885.
Serfraz, A., Qamruzzaman, M., & Karim, S. (2023). Revisiting the nexus between economic policy uncertainty, financial development, and FDI inflows in Pakistan during covid-19: Does clean energy matter? *Int. J. Energy Econ. Policy*, *13*(4), 91–101. https://doi.org/10.32479/ijeep.14360.
Shabir, M., Ali, M., Hashmi, S. H., & Bakhsh, S. (2022). Heterogeneous effects of economic policy uncertainty and foreign direct investment on environmental quality: Cross-country evidence. *Environ. Sci. Pollut. Res.*, *29*(2), 2737–2752. https://doi.org/10.1007/s11356-021-15715-3.
Shafiullah, M., Miah, M. D., Alam, M. S., & Atif, M. (2021). Does economic policy uncertainty affect renewable energy consumption? *Renew. Energy*, *179*, 1500–1521. https://doi.org/10.1016/j.renene.2021.07.092.
Shah, A. A. & Zha, D. (2025). Economy-wide estimates of the energy rebound effect in BRICS: The role of environmental regulations and economic policy uncertainty. *Energy*, *320*, 135276. https://doi.org/10.1016/j.energy.2025.135276.
Shah, S. A., Ye, X., Wang, B., & Wu, X. (2024). Dynamic linkages among carbon emissions, artificial intelligence, economic policy uncertainty, and renewable energy consumption: Evidence from East Asia and Pacific countries. *Energies*, *17*(16), 4011. https://doi.org/10.3390/en17164011.
Syed, Q. R. & Bouri, E. (2022). Impact of economic policy uncertainty on CO_2 emissions in the US: Evidence from bootstrap ARDL approach. *J. Public Aff.*, *22*(3), e2595. https://doi.org/10.1002/pa.2595.
Udeagha, M. C. & Muchapondwa, E. (2022). Investigating the moderating role of economic policy uncertainty in environmental Kuznets curve for South Africa: Evidence from the novel dynamic ARDL simulations approach. *Environ. Sci. Pollut. Res.*, *29*(51), 77199–77237. https://doi.org/10.1007/s11356-022-21107-y.
Udeagha, M. C. & Muchapondwa, E. (2023). Environmental sustainability in South Africa: Understanding the criticality of economic policy uncertainty, fiscal decentralization, and green innovation. *Sustain. Dev.*, *31*(3), 1638–1651. https://doi.org/10.1002/sd.2473.
Ullah, S., Ali, K., Shah, S. A., & Ehsan, M. (2022). Environmental concerns of financial inclusion and economic policy uncertainty in the era of globalization: Evidence from low & high globalized OECD economies. *Environ. Sci. Pollut. Res.*, *29*(24), 36773–36787. https://doi.org/10.1007/s11356-022-18758-2.
Vitenu-Sackey, P. A. & Acheampong, T. (2022). Impact of economic policy uncertainty, energy intensity, technological innovation and R&D on CO_2 emissions: Evidence from a panel of 18 developed economies. *Environ. Sci. Pollut. Res.*, *29*(58), 87426–87445. https://doi.org/10.1007/s11356-022-21729-2.
Wang, C., Abbasi, K. R., Irfan, M., Ben-Salha, O., & Bandyopadhyay, A. (2024a). Navigating sustainability in the US: A comprehensive analysis of green energy, eco-innovation, and economic policy uncertainty on

sectoral CO_2 emissions. *Energy Rep.*, *11*, 5286–5299. https://doi.org/10.1016/j.egyr.2024.05.014.
Wang, C., Li, T., Sensoy, A., Cheng, F., & Fang, Z. (2024b). Economic policy uncertainty and options market participation: Hedge or speculation? *Borsa Istanb. Rev.*, *24*, 50–59. https://doi.org/10.1016/j.bir.2024.04.006.
Wang, H. J., Geng, Y., Xia, X. Q., & Wang, Q. J. (2021). Impact of economic policy uncertainty on carbon emissions: Evidence from 137 multinational countries. *Int. J. Environ. Res. Public Health*, *19*(1), 4. https://doi.org/10.3390/ijerph19010004.
Wang, J., Xu, Q., Sibt-e-Ali, M., Shahzad, F., & Ayub, B. (2023). How economic policy uncertainty and geopolitical risk affect environmental pollution: Does renewable energy consumption matter? *Environ. Sci. Pollut. Res.*, *30*(45), 101858–101872. https://doi.org/10.1007/s11356-023-29553-y.
Wei, F., Sial, M. S., Haider, S. N., & Matac, L. M. (2023). Nexus of economic policy uncertainty, economic expansion and clean energy consumption and their role in car bon neutrality of emerging economies. *Geol. J.*, *58*(9), 3250–3258. https://doi.org/10.1002/gj.4688.
Wei, W., Hu, H., & Chang, C. P. (2022). Why the same degree of economic policy uncertainty can produce different outcomes in energy efficiency? New evidence from China. *Struct. Change Econ. Dyn.*, *60*, 467–481. https://doi.org/10.1016/j.strueco.2022.01.001.
Wen, Q. & Zhang, T. (2022). Economic policy uncertainty and industrial pollution: The role of environmental supervision by local governments. *China Econ. Rev.*, *71*, 101723. https://doi.org/10.1016/j.chieco.2021.101723.
Wu, Y., Anwar, A., Quynh, N. N., Abbas, A., & Cong, P. T. (2024). Impact of economic policy uncertainty and renewable energy on environmental quality: Testing the LCC hypothesis for fast growing economies. *Environ. Sci. Pollut. Res.*, *31*(25), 36405–36416. https://doi.org/10.1007/s11356-023-30109-3.
Wüstenfeld, J. & Geldner, T. (2022). Economic uncertainty and national bitcoin trading activity. *N. Am. J. Econ. Finance*, *59*, 101625. https://doi.org/10.1016/j.najef.2021.101625.
Xin, D. & Xin, L. (2022). The impact of economic policy uncertainty on PM2.5 pollution—Evidence from 25 countries. *Environ. Sci. Pollut. Res.*, *29*(25), 38126–38142. https://doi.org/10.1007/s11356-022-18599-z.
Xu, M., Farooq, U., Tabash, M. I., & Aljughaiman, A. A. (2024). How does economic policy uncertainty influence energy policy? The role of financial sector development. *Energy Strategy Rev.*, *55*. https://doi.org/10.1016/j.esr.2024.101523.
Xue, C., Shahbaz, M., Ahmed, Z., Ahmad, M., & Sinha, A. (2022). Clean energy consumption, economic growth, and environmental sustainability: What is the role of economic policy uncertainty? *Renew. Energy*, *184*, 899–907. https://doi.org/10.1016/j.renene.2021.12.006.
Yang, W., Zhang, Y., & Hu, Y. (2022). Heterogeneous impact of economic policy uncertainty on provincial environmental pollution emissions in China. *Sustainability*, *14*(9), 4923. https://doi.org/10.3390/su14094923.
Yang, X., Chen, G., Qu, C., Chen, Z., Wen, Y., Shi, L., & Long, F. (2024). Economic policy uncertainty and Co-Control of air pollutants and CO_2: Evidence from 282 cities in China. *Energies*, *17*(11), 2675. https://doi.org/10.3390/en17112675.
Yi, S., Raghutla, C., Chittedi, K. R., & Fareed, Z. (2023). How economic policy uncertainty and financial development contribute to renewable energy consumption? The importance of economic globalization. *Renew. Energy*, *202*, 1357–1367. https://doi.org/10.1016/j.renene.2022.11.089.
You, S., Li, Z., & Wang, J. (2023). Exploring the impacts of economic policy uncertainty, natural resources, and energy structure on ecological footprints: Evidence from G-10 nations. *Environ. Sci. Pollut. Res.*, *30*(16), 45701–45710. https://doi.org/10.1007/s11356-023-25392-z.
Yu, Y., Jian, X., Wang, H., Jahanger, A., & Balsalobre-Lorente, D. (2024). Unraveling the nexus: China's economic policy uncertainty and carbon emission efficiency through advanced multivariate quantile-on-quantile regression analysis. *Energy Policy*, *188*, 114057. https://doi.org/10.1016/j.enpol.2024.114057.
Zahra, S. & Badeeb, R. A. (2022). The impact of fiscal decentralization, green energy, and economic policy uncertainty on sustainable environment: A new perspective from ecological footprint in five OECD countries. *Environ. Sci. Pollut. Res.*, *29*(36), 54698–54717. https://doi.org/10.1007/s11356-022-19669-y.
Zeng, Q. & Yue, X. (2022). Re-evaluating the asymmetric economic policy uncertainty, conventional energy, and renewable energy consumption nexus for BRICS. *Environ. Sci. Pollut. Res.*, *29*(14), 20347–20356. https://doi.org/10.1007/s11356-021-17133-x.
Zhang, D., Zhao, F., Leow, H. W., & Al-Naimi, A. A. (2024a). Nexus between mineral rents and environmental sustainability: The role of economic policy uncertainty. *Nat. Resour. Forum*, *49*(4), 3728–3742. https://doi.org/10.1111/1477-8947.12547.
Zhang, M., Abbasi, K. R., Inuwa, N., Sinisi, C. I., Alvarado, R., & Ozturk, I. (2023a). Does economic policy uncertainty, energy transition and ecological innovation affect environmental degradation in the United States? *Econ. Res. Ekon. Istraz.*, *36*(2). https://doi.org/10.1080/1331677X.2023.2177698.
Zhang, P. & Xiao, Y. (2024). The impact of economic policy uncertainty, renewable energy adoption, and eco-innovation on sectoral CO_2 emissions in the United States. *Energy Strategy Rev.*, *56*, 101593. https://doi.org/10.1016/j.esr.2024.101593.

Zhang, R. J. & Razzaq, A. (2022). Influence of economic policy uncertainty and financial development on renewable energy consumption in the BRICST region. *Renew. Energy*, *201*, 526–533. https://doi.org/10.1016/j.renene.2022.10.107.

Zhang, Y., Huang, Y., & Wang, X. (2023b). Impact of economic policy uncertainty, oil prices, and technological innovations on natural resources footprint in BRICS economies. *Resour. Policy*, *86*, 104082. https://doi.org/10.1016/j.resourpol.2023.104082.

Zhang, Y., Liu, L., Lan, M., Su, Z., & Wang, K. (2024b). Climate change and economic policy uncertainty: Evidence from major countries around the world. *Econ. Anal. Policy*, *81*, 1045–1060. https://doi.org/10.1016/j.eap.2024.02.003.

Zhang, Y., Qamruzzaman, M., Karim, S., & Jahan, I. (2021). Nexus between economic policy uncertainty and renewable energy consumption in BRIC nations: The mediating role of foreign direct investment and financial development. *Energies*, *14*(15), 4687. https://doi.org/10.3390/en14154687.

Zhang, Z., Hao, L., Linghu, Y., & Yi, H. (2023c). Research on the energy poverty reduction effects of green finance in the context of economic policy uncertainty. *J. Clean. Prod.*, *410*, 137287. https://doi.org/10.1016/j.jclepro.2023.137287.

Zhou, X., Jia, M., Altuntaş, M., Kirikkaleli, D., Hussain, M. (2022). Transition to renewable energy and environmental technologies: The role of economic policy uncertainty in top five polluted economies. *J. Environ. Manage.*, *313*, 115019. https://doi.org/10.1016/j.jenvman.2022.115019.