“The role of energy prices in the Environmental Kuznets Curve framework: A systematic review and bibliometric analysis”

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THE ROLE OF ENERGY PRICES IN THE ENVIRONMENTAL KUZNETS CURVE FRAMEWORK: A SYSTEMATIC REVIEW AND BIBLIOMETRIC ANALYSIS

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Abstract

Energy prices are a crucial factor influencing the emissions–income nexus. Hence, this study aims to examine the environmental effects of energy prices within the Environmental Kuznets Curve (EKC) framework through bibliometric analysis and narrative synthesis of empirical studies. For this purpose, 67 Scopus-indexed documents published during 1997–2025 are analyzed. The bibliometric findings reveal that publications have grown at an exponential rate since 2016, peaking at 10 articles in 2023. Bradford's Law analysis identifies that Environmental Science and Pollution Research is the leading source. Moreover, Lotka's Law shows that nearly 75% of authors contributed only one or two studies, indicating a diverse research community. Citation analysis further reveals high global citations but limited local citations, suggesting strong external visibility but relatively weak internal connectivity. Thematic analysis identifies carbon dioxide emissions and renewable energy as dominant motor themes, showing increasing scholarly interest in the renewable energy transition due to high energy prices. The empirical synthesis shows that the EKC hypothesis and environmental benefits of high prices are more frequently validated in energy-importing advanced economies. In contrast, studies on energy-exporting economies often fail to validate the EKC hypothesis or report N-shaped EKC patterns, together with adverse environmental effects of energy prices. Overall, the review concludes that the environmental impact of energy prices within the EKC framework varies according to economic development and energy-trade status.

Keywords Environmental Kuznets Curve hypothesis, bibliometric analysis, energy prices, economic growth, emissions

JEL Classification Q41, Q43, O44

INTRODUCTION

The current scenario of environmental degradation has painted a grim picture around the globe. Research on reducing ecological footprints while maintaining an adequate level of economic development has been on the rise for the last four decades. Fossil fuels are a major cause of pollution, which are actively used by many countries to manage energy demand. Their consumption in the form of oil, gas, and coal contributes to different levels of emissions across sectors, with the industrial sector leading others. Under such conditions, fossil fuel activities have resulted in severe ecological losses over the past few decades.

One way to facilitate the energy transition is to raise fossil fuel prices and alter consumption patterns. Scientists are closely monitoring price trends across sectors and nations to find evidence of a shift toward sustainable energy. High energy costs have already proven to be a driver of eco-innovation in European countries (Horbach et al., 2012), but the same may not hold for other economic structures. Thus,

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markets face a non-linear trend when shifting to renewable alternatives, which has implications on a global scale, with oil price shocks being the most influential factor for sustainable markets.

The Environmental Kuznets Curve (EKC) is determined by various economic factors, including energy prices, that can affect emissions and shape the EKC pattern. The EKC literature is trying to find ways to validate it for a better chance of transitioning to renewable sources. However, Gross Domestic Product (GDP) per capita and natural resource exploitation have consistently shown a heterogeneous connection to the curve, which is responsible for the delay in the first phase of the EKC. Moreover, energy prices are also an important factor influencing environmental quality and the EKC.

The literature has investigated the EKC hypothesis by applying synthesized reviews and bibliometric analyses. However, a comprehensive analysis is missing on the environmental effects of energy prices within the EKC framework. Thus, this paper synthesizes the empirical evidence on how energy prices shape the EKC and uses bibliometric methods to map the intellectual structure and thematic evolution of this literature.

1. LITERATURE REVIEW

Grossman and Krueger (1991) introduced the nonlinear connection between economic progress and emissions. Due to this nonlinear relationship, Panayotou (1993) termed it the EKC hypothesis, which was inspired by the nonlinear relationship between economic progress and income inequality proposed by Kuznets (1955). The EKC hypothesis explains that environmental degradation may initially rise with income growth. However, after touching a turning point, it may also decline as economies invest in cleaner technologies. Since the early 1990s, the EKC hypothesis has attracted considerable scholarly attention in the empirical literature, and studies have employed various environmental proxies, econometric methodologies, and control variables. This growing empirical literature has also attracted numerous review studies employing systematic, bibliometric, and meta-analytic methods.

1.1. Systematic, meta-analytic, and bibliometric reviews on the EKC hypothesis

The review studies have synthesized the EKC literature by identifying conceptual trends, intellectual structures, methodological gaps, and contextual factors shaping environmental outcomes. Ginevičius et al. (2017) conducted a review study and identified key theoretical developments and empirical evidence to achieve a sustainable growth path in the EKC literature. The study also documented how the EKC hypothesis evolved from a simple bivariate relationship to complex multivariate models. Leal and Marques (2022) provided a critical methodological review of EKC studies. They found that inconsistencies in model specifications (functional forms) and variable selection (environmental proxies) across studies explained the differing outcomes of the EKC hypothesis.

Beyond general EKC syntheses, review studies have also examined specific conditioning factors that may affect the validity of the EKC hypothesis. Sun et al. (2023) performed a meta-analysis on the impact of urbanization on fine Particulate Matter. The study reported that most EKC literature hypothesized a linear effect of urbanization in the EKC, which introduced specification bias in the models and led to heterogeneity in the validity of the EKC across different urban contexts. Chaudhry and Reetu (2025) systematically reviewed 50 studies on the trade-environment nexus within the EKC framework. The literature showed heterogeneous effects of trade on the EKC framework. This heterogeneity highlighted the need to promote clean energy transitions and improve institutional quality, which could translate into the positive environmental effects of trade. Wiedenhofer et al. (2020) reviewed 835 papers on the role of resource use in the EKC framework. The review highlighted that most studies focused on econometric methodologies and ignored the thermodynamic principles governing energy and material flows in the EKC framework. The study argued that incorporating biophysical perspectives was essential for understanding the decoupling of income from emissions.

Liobikienė (2020) investigated how income inequality affected emissions within the EKC framework. The paper identified a methodological gap in investigating production-based emissions. It suggested using a consumption-based approach in validating the EKC, as wealthy nations might outsource emissions to poorer countries. Saini and Singhania (2019) conducted a systematic review of 111 documents investigating the role of Foreign Direct Investment (FDI) in the EKC framework. The analysis revealed that cleaner FDI mitigated the adverse environmental effects of growth and supported EKC validation. However, FDI in extractive and heavy industries tended to invalidate the EKC hypothesis. Ramakrishna et al. (2020) conducted a systematic review on the EKC framework. They found that excessive utilization of resources was responsible for biodiversity loss, which resulted in the invalidity of the EKC. The study emphasizes that sustainable resource management is a prerequisite for achieving the second phase of the EKC.

Review studies have also explored regional heterogeneity within the EKC framework by focusing on specific economies and geographic contexts. For instance, AlKhars et al. (2022) examined 38 Gulf Cooperation Council (GCC) studies. The study found mixed evidence of the EKC, which was due to using different control variables within the EKC framework. Moreover, the choice between panel versus individual country analyses affected the EKC outcomes. It was also concluded that oil dependence significantly moderated EKC dynamics. Mahmood et al. (2023a) systematically reviewed Chinese EKC studies. The study concluded that using global pollution proxies and disaggregated regional analyses of China helped to validate a more stable EKC compared to aggregated national analyses. Thus, measurement choices also affected the EKC validity.

In addition to systematic reviews, studies using bibliometric analysis have mapped the intellectual structure and publication trends of the EKC literature. Ajmi et al. (2023) applied bibliometric analysis to map the EKC literature by selecting 200 studies. They found that Ilhan Ozturk, among others, was the most influential author in the empirical EKC literature. In addition, China, the United States (US), and European nations produced the most scientific output. Furthermore, carbon dioxide (CO2) emissions, economic progress, and renewable sources were major motor themes driving the EKC literature. Sarkodie and Strezov (2019) combined bibliometric and meta-analytical approaches to evaluate the EKC literature. The bibliometric analysis confirmed that "China" was the most frequently used term in titles, abstracts, and keywords. The analysis also identified the most influential contributing authors in terms of citation count. The meta-analysis identified a turning point of the EKC at a GDP per capita of 8,910 dollars, and high-income economies were mostly found to be in the second phase of the EKC. However, low-income economies showed a lower tendency to experience this shift.

Naveed et al. (2022) conducted a bibliometric-based systematic review and analyzed 1,654 EKC studies. The authors confirmed that most studies validated the EKC, with an average turning point at a GDP per capita of 9,260 dollars. Moreover, the bibliometric analysis also identified the most influential papers, authors, and journals. Belgibayeva et al. (2025) conducted a bibliometric analysis on 28,761 studies investigating the role of different energy sources on environmental outcomes. The study found that publications followed an exponential growth trend after 2014. Authors from China, India, and the US were the leading contributors to the literature. A significant increase in international collaboration was also observed. For instance, 25% of the papers involved authors from different countries. In addition, energy journals were the major platforms for publishing the research.

Overall, the review literature highlights substantial methodological diversity and contextual heterogeneity in EKC research, underscoring the importance of specific conditional factors in shaping EKC outcomes.

1.2. Synthesis of empirical evidence on energy prices and environmental quality in the EKC framework

Despite extensive reviews of the EKC hypothesis, limited attention has been given to synthesizing the environmental effects of energy prices within

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the EKC framework. The current geopolitical tensions and energy market volatility highlight the need for a synthesis to understand the dynamics of energy prices in the EKC framework. Energy prices may have diverse effects on emissions and the validity of the EKC, depending on whether economies are energy-importing or energy-exporting.

1.2.1. Energy-importing advanced economies

The literature on energy-importing advanced economies provides the most theoretically coherent evidence regarding the effect of energy prices in the EKC framework. For instance, higher energy prices reduced emissions and supported the inverted-U EKC in G7 economies (Ike et al., 2020), G6 economies (Nguyen et al., 2020), OECD (Richmond & Kaufmann, 2006; Erdogan et al., 2020; Zaghdoudi, 2017), industrialized economies (Knorre et al., 2021), G20 economies (Bilgili & Barak, 2025), major emitters (Shahbaz et al., 2024), and advanced importing economies (Ozkan & Okay, 2024; Qamruzzaman et al., 2025). However, Rodriguez et al. (2016) found that incorporating energy prices in the EKC framework of OECD weakened the EKC validity, but energy prices still reduced emissions. The differing results in the case of OECD studies stemmed from variations in model specifications, time periods, and energy-price indicators. For instance, Erdogan et al. (2020) captured energy-efficiency improvements and structural changes, which were ignored by considering only income effects (Rodriguez et al., 2016).

Some country-specific evidence also reported that higher energy prices reduced emissions with the support of the EKC validity in the US (Franklin & Ruth, 2012; Jeon, 2022; Ozcan et al., 2024; Boufateh, 2019; Malik & Butt, 2025), Italy (Javed et al., 2023), and Norway (Koilo, 2019). Adedoyin et al. (2021) validated the EKC, but coal rents and transport activity increased emissions in the US. However, Shahbaz et al. (2017) found an N-shaped EKC in the US, which suggested that emissions rose again at advanced stages of development. Thus, the N-shaped curve, instead of the conventional inverted-U-shaped, reflects energy rebound effects at higher income levels. Moreover, the functional form assumption (quadratic or cubic) also explained the variation in EKC outcomes in the US-based studies. In sectoral evidence from Europe, higher energy prices reduced energy usage in transportation (Pablo-Romero et al., 2017a), residential households (Borozan, 2018, 2019), and hotels and restaurants (Pablo-Romero et al., 2017b). Moreover, these studies validated the EKC except for Pablo-Romero et al. (2017b). The absence of EKC validation in the hotel and restaurant sector reflected the relatively low technological adaptation and limited energy-substitution capacity in this sector.

The consistency of the negative impact of energy prices on emissions reflects that these economies possess substantial renewable-energy and technological capacity, which helps them with their renewable energy transition when energy prices rise. Nevertheless, heterogeneous econometric frameworks and model specifications were found responsible for different empirical findings in OECD and US-based studies.

1.2.2. Energy-exporting economies

The literature on energy-exporting economies shows a different pattern from importing advanced economies. In a comparative study, Tokpah et al. (2024) found that higher oil prices reduced emissions in importing economies through cost-push and substitution effects. However, the study further reported that higher oil prices increased emissions in exporting economies through revenue-expansion effects. The positive effect of energy prices on emissions was largely explained through the resource-curse mechanism in energy-exporting economies (Sadik-Zada & Loewenstein, 2020). For instance, higher global energy prices increased export revenues, government expenditure, industrial expansion, and fossil-fuel dependence in resource-rich economies (Tabash et al., 2023), which would increase emissions. Moreover, some exporting countries are subsidizing domestic fuel prices (Mahmood et al., 2023b). Thus, higher international prices would not generate strong cost-push incentives to reduce fossil-fuel consumption. Moreover, Esmaeili and Abdollahzadeh (2009) claimed that ignoring energy prices in such economies might lead to omitted variable bias in the EKC framework.

In line with the above arguments, most studies on energy-exporting economies reported that higher oil prices or resource rents increased emissions in Organization of Petroleum Exporting

Countries (OPEC) economies (Onifade et al., 2021; Mahmood & Saqib, 2022; Moutinho et al., 2020), GCC economies (Tabash et al., 2023), oil-producing Asian economies (Husaini et al., 2021), broader oil-exporting panel (Sadik-Zada & Loewenstein, 2020), and MENA economies (Mahmood et al., 2023b). Moreover, some country-level studies also found the same patterns in Algeria (Bouznit & Pablo-Romero, 2016; Layachi, 2019), Tunisia (Boufateh, 2021), Saudi Arabia (Issaoui et al., 2024), and Qatar (Mrabet et al., 2017). Some studies with contradictory findings reported the negative impact of energy prices in OPEC economies (Saboori et al., 2016) and the GCC region (Ebaid et al., 2022). These contrasting findings were due to structural reforms, renewable-energy investments, and decarbonization strategies in some GCC and OPEC economies (Tabash et al., 2023; Mahmood & Saqib, 2022), which were ignored in other studies (Saboori et al., 2016; Ebaid et al., 2022).

In country-specific studies, the negative impact of energy prices was also reported in Venezuela (Udemba & Yalçıntaş, 2023) and Saudi Arabia (Aljadani et al., 2021). These contradictory findings suggest that resource revenues were increasingly directed toward renewable-energy investment and diversification strategies in the GCC region (Aljadani et al., 2021). Moreover, methodological frameworks also shaped the different effects of energy prices on emissions (Aljadani et al., 2021; Issaoui et al., 2024; Saboori et al., 2016). Thus, the energy-exporting literature shows a heterogeneous impact of energy prices. Similarly, the outcomes of the EKC are also heterogeneous. Most studies corroborated the EKC even in the presence of the positive effect of energy prices. Nevertheless, the EKC was not validated in OPEC economies (Saboori et al., 2016), the GCC region (Ebaid et al., 2022), Venezuela (Udemba & Yalçıntaş, 2023), and Saudi Arabia (Aljadani et al., 2021). The failure to validate the EKC in some exporting economies indicated persistent dependence on carbon-intensive production structures, limited structural transformation, and weak environmental governance.

1.2.3. Global panels

Most economies in the global sample are net energy importers, and high energy prices created a cost-push effect in the global sample, which helped reduce aggregate demand and energy consumption (Franzen & Mader, 2016; Feng et al., 2017). Thus, most large-panel global studies concluded that higher energy prices reduced emissions (Feng et al., 2017; Franzen & Mader, 2016; Zhao et al., 2022; Shahnazi et al., 2024; Bilgili & Barak, 2025). However, the outcomes regarding the EKC remain mixed. The EKC was not validated in this heterogeneous global panel (Franzen & Mader, 2016; Feng et al., 2017; Serino, 2022), which reflected structural differences associated with the large presence of developing economies in the global sample.

Some studies also validated the inverted-U EKC (Zhao et al., 2022; Shahnazi et al., 2024; Bilgili & Barak, 2025). These studies generally emphasized the role of technological progress and renewable-energy adoption in reducing emissions, which helped validate the EKC. Moreover, differences in variable selection, sample composition, and econometric estimation techniques also contributed to the contrasting EKC outcomes in global panels. In addition, Moomaw and Unruh (1997) and Pilar et al. (2025) found an N-shaped EKC, which showed the importance of introducing a cubic income-emissions relationship in the EKC framework. The N-shaped curve also showed energy rebound effects at a higher level of income. Thus, emissions declined at the second stage but rose again at the third stage of the EKC. Furthermore, differences in income levels, industrial structures, institutional quality, energy dependence, and environmental regulations across global economies weakened the existence of the inverted-U-shaped EKC.

Overall, the literature finds a consistent negative impact of higher energy prices on emissions due to the dominance of energy-importing economies in the global sample. However, the validity of the EKC was mixed due to the heterogeneous nature of the global panels. Moreover, methodological differences and the assumption of a cubic functional form also explained the inconsistent EKC findings across global studies.

1.2.4. Emerging and developing economies

The literature on emerging and developing economies exhibits the greatest degree of heterogeneity due to rapid industrialization, uneven insti-

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tutional quality, and different technological development and energy-transition capacity. The studies reported that higher energy prices reduced emissions and supported the EKC hypothesis in emerging importer economies (Naimoglu, 2022, 2023), newly industrialized countries (Xu et al., 2024; Bashir et al., 2024), BRICS economies with diversification and transition policies (Danish et al., 2020; Qamruzzaman et al., 2025), Malaysia (Bi et al., 2025), Pakistan (Malik et al., 2020), and broader developing-country panels (Zhao et al., 2022; Nguea, 2023). Thus, rising energy prices accelerated industrial upgrading, renewable-energy adoption, diversification, and energy-efficiency improvements in these transitional economies. However, the magnitude of these effects varied across emerging economies, depending on institutional quality, energy-market reforms, and access to clean technologies (Naimoglu, 2022, 2023).

Studies on China showed different results. For instance, higher energy prices reduced emissions and validated the EKC using aggregate Chinese national data (Joof et al., 2023; Mahajan & Sah, 2025). Conversely, Wei et al. (2022) reported that higher energy prices increased emissions among Chinese firms despite EKC validation. It highlighted the importance of disaggregated analysis in finding robust results, as industrial firms may respond to higher energy prices through production expansion and cost pass-through rather than energy substitution. Thus, differences between firm-level and aggregate national-level analyses produced contrasting results. National data capture long-run structural adjustments, whereas firm-level data reflect short-run production responses and sector-specific energy dependence as well. In the case of Africa, the literature also exposes different findings. For instance, Erdogan (2024) reported positive effects of oil prices for 13 African economies. However, expanding the sample to 35 African economies, Nguea (2023) found that higher oil prices reduced emissions. Thus, contrasting findings reflected differences in sample composition. Moreover, variations in fuel subsidies, renewable-energy penetration, trade openness, and political stability also contributed to the heterogeneous environmental effects of energy prices.

In other developing economies, higher energy prices increased emissions despite EKC validation in Indonesia (Nugraha et al., 2024), Liberia (Gbatu et al., 2019), and African economies (Erdogan, 2024). These results were found due to weak environmental institutions and industrial structures dominated by energy-intensive sectors. Thus, higher energy prices increased production costs without generating sufficient technological upgrading. Conversely, Tran et al. (2023) reported an insignificant impact of energy prices on emissions and failed to corroborate the EKC in Vietnam. Thus, the transmission mechanism of energy prices was weak in economies with limited structural transformation, which reduced the chance of the EKC being valid. The evidence from emerging and developing economies suggests that the environmental impact of energy prices is highly conditional on institutional quality, energy-market structures, industrial composition, and the pace of structural transformation. However, the validity of the EKC is more stable in these economies. Nevertheless, heterogeneity in empirical findings arises from methodological choices, sectoral composition, policy frameworks, and the stage of economic development across emerging and developing economies.

Overall, the empirical literature reveals heterogeneous effects of energy prices on emissions and EKC outcomes across different economic structures, development levels, and energy-trade profiles. Although prior review studies synthesized the roles of trade, urbanization, FDI, income inequality, and biodiversity within the EKC framework (Sun et al., 2023; Chaudhry & Reetu, 2025; Wiedenhofer et al., 2020; Liobikienė, 2020; Saini & Singhania, 2019; Ramakrishna et al., 2020), they did not synthesize the role of energy prices in the EKC framework. Therefore, the present study fills this gap by systematically synthesizing the empirical evidence on energy prices and environmental quality within the EKC framework across diverse economic contexts.

2. METHOD

2.1. Data collection and screening procedure

The data were obtained from the Scopus database, which is recognized as one of the most comprehensive bibliometric databases in terms of metadata coverage (Delgado-Quirós & Ortega, 2024). The PRISMA methodology proposed by Liberati et al. (2009) was followed for data collection and study selection. Figure 1 shows the PRISMA protocol. By providing a comprehensive set of terminologies related to energy prices and the EKC, the following search string was applied in October 2025 to capture publications related to the environmental impact of energy prices in the EKC framework:

[TITLE-ABS-KEY("energy price" OR "oil rent" OR "oil revenue" OR "oil price" OR "gas rent" OR "gas revenue" OR "gas price" OR "coal rent" OR "coal revenue" OR "coal price" OR "petroleum price" OR "fossil fuel price" OR "renewable energy price" OR "resource rent" OR "electricity price" OR "energy subsidies" OR "energy tax" OR "carbon taxes") AND TITLE-ABS-KEY("emissions" OR "pollution" OR "environment" OR "carbon dioxide emissions" OR "CO2 emissions" OR "greenhouse gas emissions" OR "GHG emissions" OR "environmental degradation" OR "ecological footprint") AND TITLE-ABS-KEY("EKC" OR "Environmental Kuznets Curve")].

The search query identified 207 documents published between 1997 and 2025. We utilized some inclusion criteria for these selected studies. For instance, the documents were written in English and categorized as research articles. The documents focused on the subject areas of economics, econometrics and finance, environmental science, and energy. These filters removed 94 articles. Moreover, the retained 113 articles were thoroughly studied for methodological soundness and sample selection. A total of 31 articles were excluded due to insufficient econometric rigor, while 15 additional

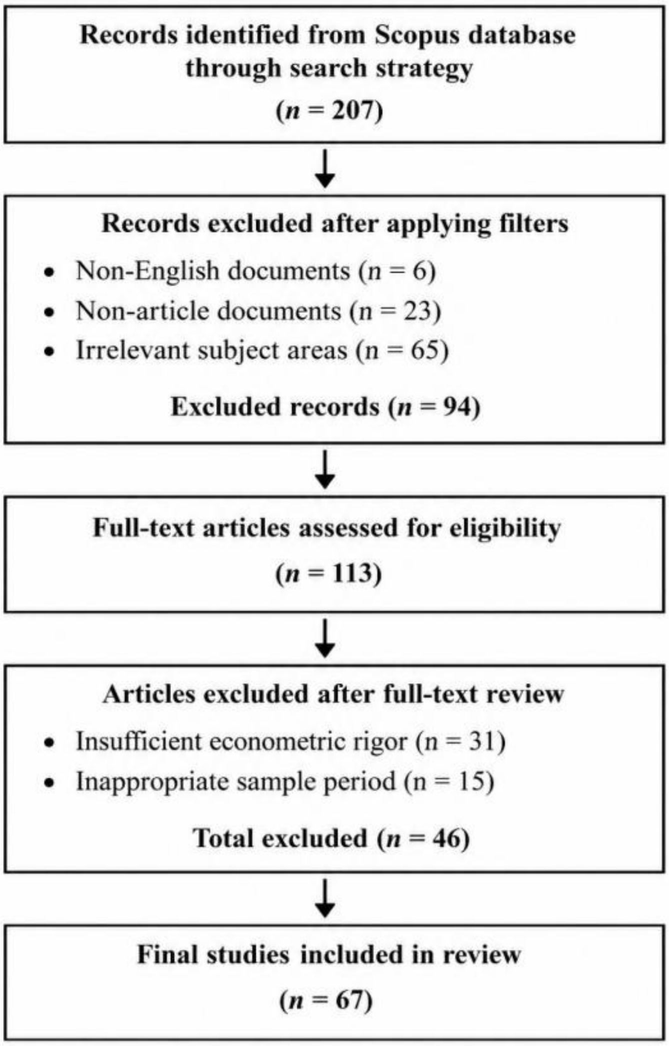

Figure 1. PRISMA diagram

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articles were removed because of inappropriate sample-period selection. Finally, 67 research articles were retained for review. We then reviewed all selected articles to extract methodological details and assess regional diversity and heterogeneity in results by sorting data period, study location, variables, and methodology. This step helped us in synthesizing the literature on energy price fluctuations, their effects on emissions, and their role in the EKC framework.

The dataset of selected 67 articles was downloaded in comma-separated values format for bibliometric analysis. Metadata completeness was assessed using the Biblioshiny application. The major metadata fields of “Abstract”, “Affiliation”, “Title”, “Authors”, “Journal”, “Digital Object Identifier (DOI)”, “Document Type”, “Publication Year”, “Language”, “Keywords”, “Cited References”, and “Total Citations” showed no missing values in Table 1. However, 8.21% of the data were missing for the “Corresponding Author” field, which may affect the analysis of country-level scientific production. Therefore, this analysis was not conducted. Moreover, 33.33% of the “Keywords Plus” data were missing. Thus, author-supplied keywords were prioritized for keyword co-occurrence and thematic mapping analysis (Belgibayeva et al., 2025; Zhang et al., 2016).

Table 1. Metadata completeness assessment

Metadata	Description	Missing %	Status
AB	Abstract	0.00	Excellent
C1	Affiliation	0.00	Excellent
AU	Author	0.00	Excellent
CR	Cited References	0.00	Excellent
DI	DOI	0.00	Excellent
DT	Document Type	0.00	Excellent
SO	Journal	0.00	Excellent
DE	Keywords	0.00	Excellent
LA	Language	0.00	Excellent
PY	Publication Year	0.00	Excellent
TI	Title	0.00	Excellent
TC	Total Citations	0.00	Excellent
RP	Corresponding Author	8.21	Good
ID	Keywords Plus	33.33	Poor

2.2. Bibliometric analysis framework

The study employed three bibliometric techniques (performance analysis, science mapping, and thematic evolution analysis) to provide a comprehensive overview of the literature. VOSviewer and Biblioshiny were utilized for bibliometric analysis and visualization. Biblioshiny is a web-based interface of the Bibliometrix package in RStudio (version 4.5.2). Moreover, Microsoft Excel was used for data preprocessing and supplementary calculations.

In the performance analysis, annual scientific production and citations from 1997 to 2025 were analyzed to identify publication growth and research impact in the EKC-energy prices literature. Moreover, Bradford’s Law was utilized to evaluate the productivity of core research sources. Bradford’s Law divided journals into three productivity zones. The first and second zones covered the most productive and moderately productive journals, respectively. However, the third zone showed peripheral journals. Author productivity was analyzed by Lotka’s Law, which showed the distribution of scientific productivity among authors. The observed author-publication frequencies were compared with the theoretical Lotka distribution. Furthermore, citation analysis was conducted with global and local analyses. Global citation analysis captured citations received across the Scopus database. Local citation analysis was based on citation relationships within the collected dataset and reflected internal scholarly influence among the selected publications.

In addition to performance analysis, science mapping methods were employed to examine conceptual and collaborative structures. These methods included keyword co-occurrence and country collaboration network analyses. Keyword co-occurrence was analyzed to map the conceptual structure. For this purpose, authors’ keywords were analyzed for co-occurrence patterns to identify thematic relationships among research topics, and the association strength method was used for normalization. Moreover, country collaboration network analysis showed shared references among nations, which reflected international collaboration patterns. Node size reflected publication volume and citation impact, and the thickness of linkages reflected coupling strength. Colors represented clusters of related entities.

Thematic analyses were further conducted to identify the evolution and structure of research themes.

To analyze the thematic structure, thematic mapping was conducted to evaluate thematic centrality and density based on keyword clusters. This approach helped identify motor, basic, niche, and emerging themes. Moreover, trend topic analysis was performed by tracking annual keyword occurrences. This analysis visualized rising and declining research interests over time. Moreover, it helped identify shifts in thematic focus and categorize topics into growing, stable, and declining themes.

3. RESULTS

This section presents the bibliometric findings in three analytical dimensions: (i) performance analysis, (ii) science mapping analysis, and (iii) thematic analysis and evolution to provide a comprehensive overview of the development, structure, and intellectual dynamics of literature on energy prices and the EKC.

3.1. Performance analyses

Figure 2 presents the evolution of publication output and citation patterns over the period 1997–2025. From 1997 to 2015, scientific production on this topic remained minimal or nearly absent. A noticeable increase is observed in 2016, followed by fluctuations between 2017 and 2020. From 2021 onward, a sharp upward trend is recorded until 2023, followed by a slight decline in 2024 and 2025. Overall, publication output follows a quadratic (U-shaped) trend with a high coefficient of determination (R^2 = 0.8121), indicating a strong long-term growth pattern.

Citation trends show a similar evolving pattern. From 1997 to 2004, citations increased steadily, reflecting early scholarly attention to the environmental effects of energy prices within the EKC framework. Between 2004 and 2016, citation growth was minimal. This was followed by fluctuating patterns until 2019. After 2019, citations show a sustained increase through 2025. Overall, the citation pattern reflects cyclical scholarly interest in the topic, where early seminal studies contributed to initial growth, followed by periods of fluctuation and renewed attention. Recent publications may not yet fully capture their citation impact due to limited exposure time. Collectively, the findings indicate an uneven but steadily accelerating growth pattern in both publications and citations, particularly after 2016.

Figure 3 reports journal distribution based on Bradford's Law. "Environmental Science and Pollution Research" published the highest number of papers on testing the environmental effect of energy prices in the EKC framework, which shows that most published literature chooses specialized

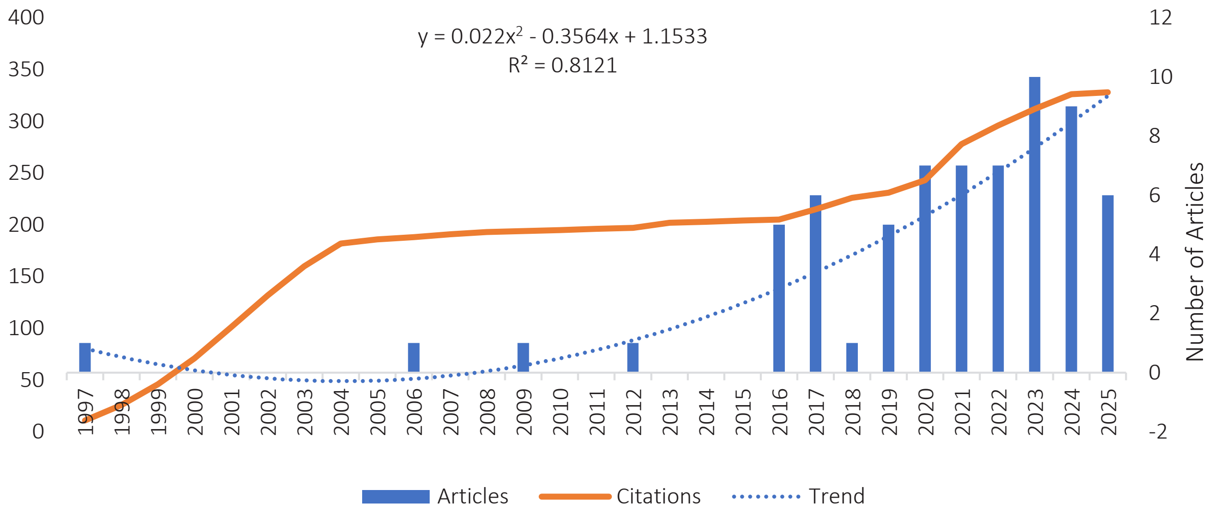

Figure 2. Annual scientific production and citation trend (scale: number of articles)

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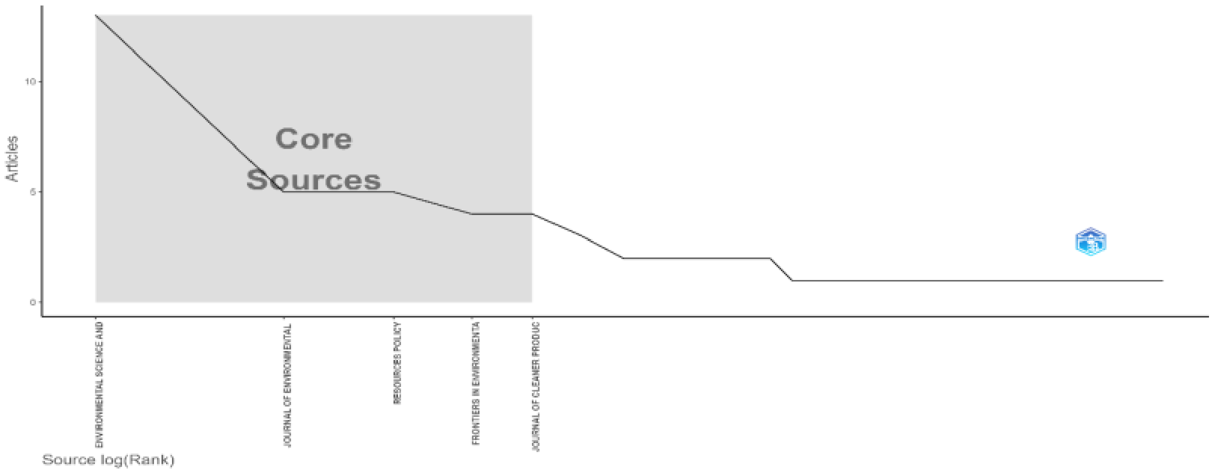

Figure 3. Core sources by Bradford's law

journals in the field of environmental sciences. The second and third positions are carried by the sources "Journal of Environmental Management" and "Resources Policy", which again reflects that energy prices mostly belong to natural resources and environmental management. However, the long tail of sources on the right-hand side highlights that the publications also choose many other journals.

Figure 4 presents author productivity patterns based on Lotka's Law. It depicts an inverse relationship between the percentage of authors and the published documents. Thus, the publication on the testing of the environmental effect of energy prices in the EKC framework follows Lotka's Law, which states that a small minority of authors publish the majority of publications. The plot shows a steep initial drop. Thus, most authors contribute only one or two publications. Moreover, the percentage of authors sharply declines with increasing number of papers, which confirms that very few researchers are highly prolific in this area. This pattern confirms a classic productivity distribution. Thus, the literature is sustained by a vast base of occasional contributors and a small group of highly productive authors. Overall, the results confirm a highly skewed authorship structure.

Figure 5 presents globally cited documents within the whole Scopus dataset. The figure shows that a few papers dominate most citations. At the top of the list, a document by Danish et al. (2020) scored 972 citations. In the second position, a document by Bednar-Friedl and Getzner (2003) got 737 citations. Moreover, the remaining eight documents

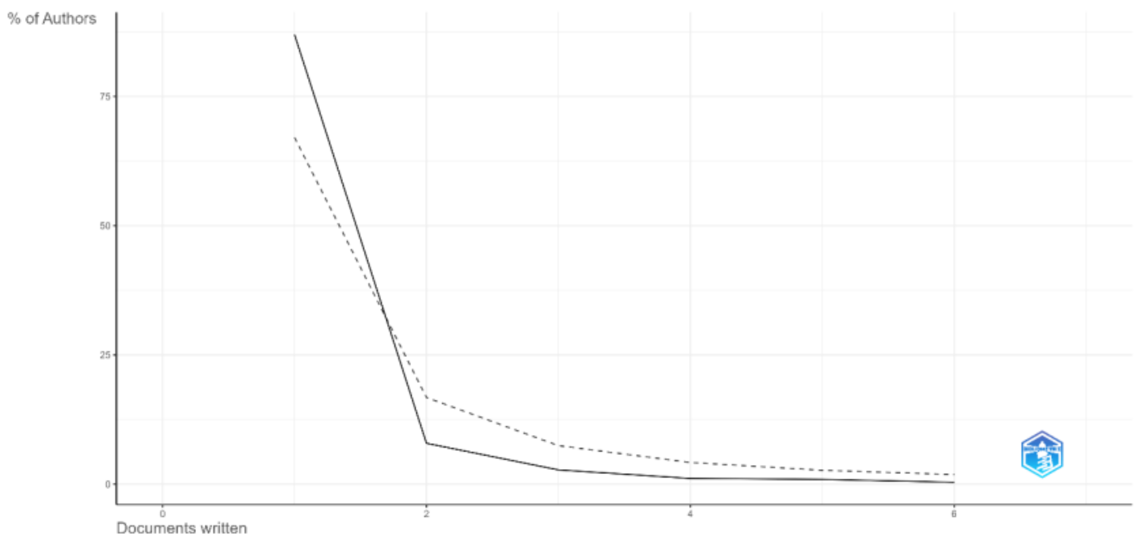

Figure 4. Author productivity analysis

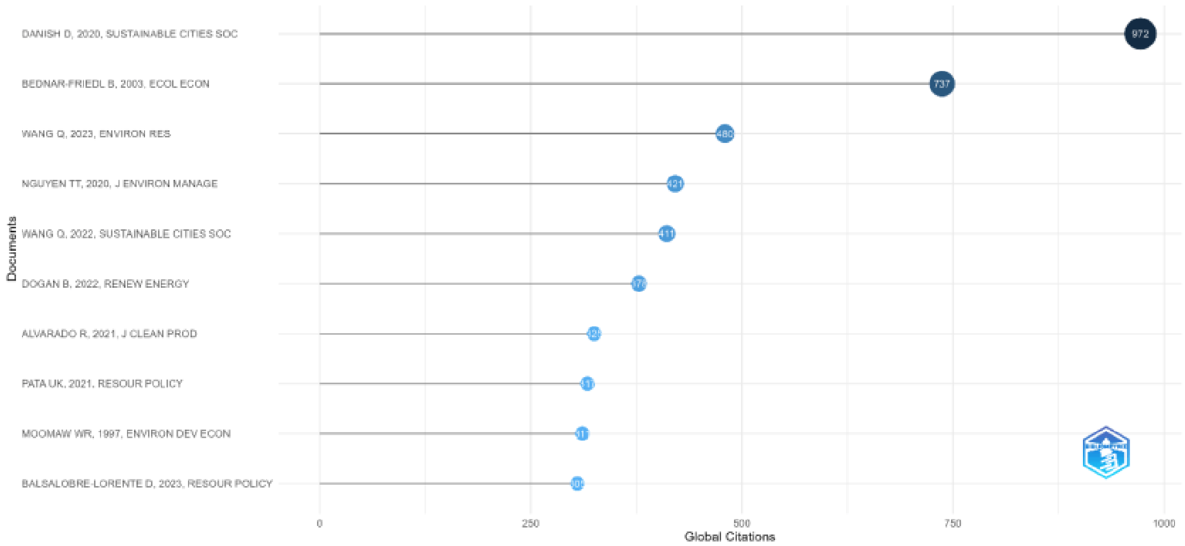

Figure 5. Most globally cited documents

by Wang et al. (2023, 2022), Dogan et al. (2022), Nguyen et al. (2020), Alvarado et al. (2021), Pata and Işık (2021), Moomaw and Unruh (1997), and Balsalobre-Lorente et al. (2023) also got more than 300 citations. This analysis shows that the literature mostly cites a few of the most dominant studies in the field of the environmental effects of energy prices within the Scopus database.

After analyzing global citations, which reflect overall scholarly impact in the Scopus database, it is also important to examine local citations that capture citation patterns within the selected corpus. Figure 6 shows that the document by Al-Mulali and Ozturk (2016) received the greatest scholarly attention, with 13 local citations. This is followed by the documents published by Alvarado et al. (2021) and Balaguer and Cantavella-Jordá (2016) with 7 local citations each. The rest of the documents, for instance, published by Adebayo et al. (2022), Balsalobre-Lorente et al. (2023), and Danish et al. (2020), got fewer citations comparatively.

One interesting finding may be noticed by comparing Figures 5 and 6: the documents by Balsalobre-Lorente et al. (2023) and Danish et al. (2020) received great scholarly attention, with global citations of 305 and 972, respectively. However, these documents attracted only two local citations with-

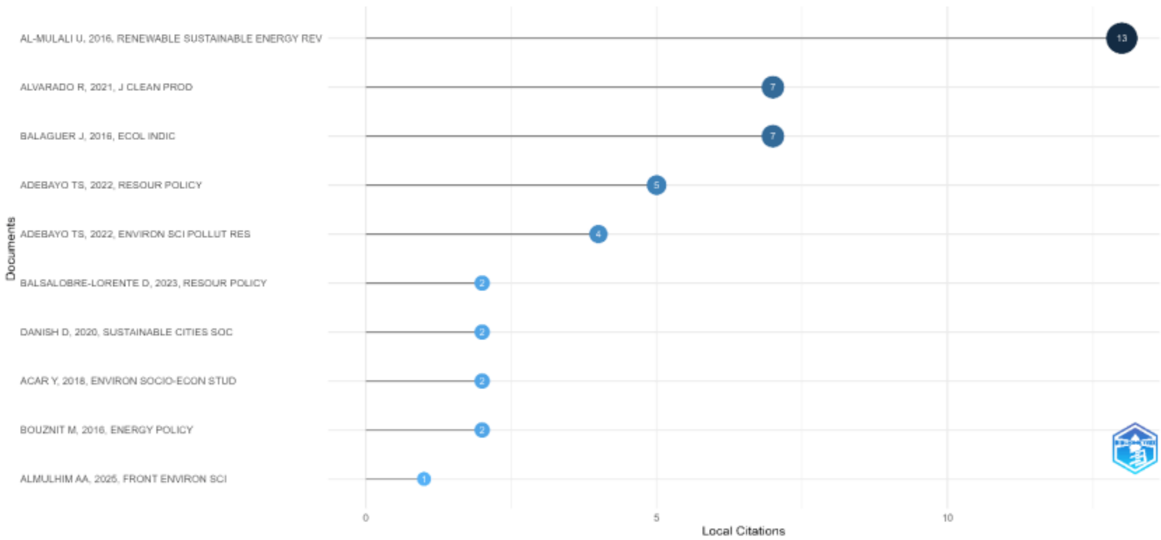

Figure 6. Most locally cited documents

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in the literature on the energy-price-EKC framework. These results suggest that the energy-price-EKC literature receives relatively fewer citations within its own research domain compared to its broader scholarly influence in the whole Scopus database.

Overall, the performance analysis reveals a highly skewed structure of scientific output, where a limited number of journals, authors, and documents account for a substantial share of research visibility and impact. While global citations highlight influential works across the Scopus database, local citations reflect internal intellectual connectivity within the specific research domain, indicating partial divergence between broader scholarly impact and field-specific influence.

3.2. Science mapping analysis

Figure 7 illustrates keyword co-occurrence patterns in the EKC and energy prices literature. The thematic structure has been organized into distinct color-coded clusters of keywords from the literature. Terms related to energy types and policy variables are coded in red to represent climate-related themes. The green cluster highlights “environmental economics”, “Kuznets curve”, and “energy policy” under a sustainability theme. “Gross domestic product” and other economic terms are included in the blue cluster, while the purple cluster covers emission-related keywords such as “carbon emission”. The yellow cluster features energy prices. Certain terms with multiple clusters represent cross-cutting focal points between environment, economy, and policy-driven research. Overall, this clustering pattern highlights that energy prices are not an isolated determinant but a cross-cutting variable that links economic activity, emissions, and policy responses within the EKC framework.

Figure 8 presents bibliographic coupling among countries. The nodes and their linkages are developed based on the target countries and regions of each research. China, the United Kingdom (UK), Turkey, and the US dominated among other countries with a wide range of interconnected scholarly

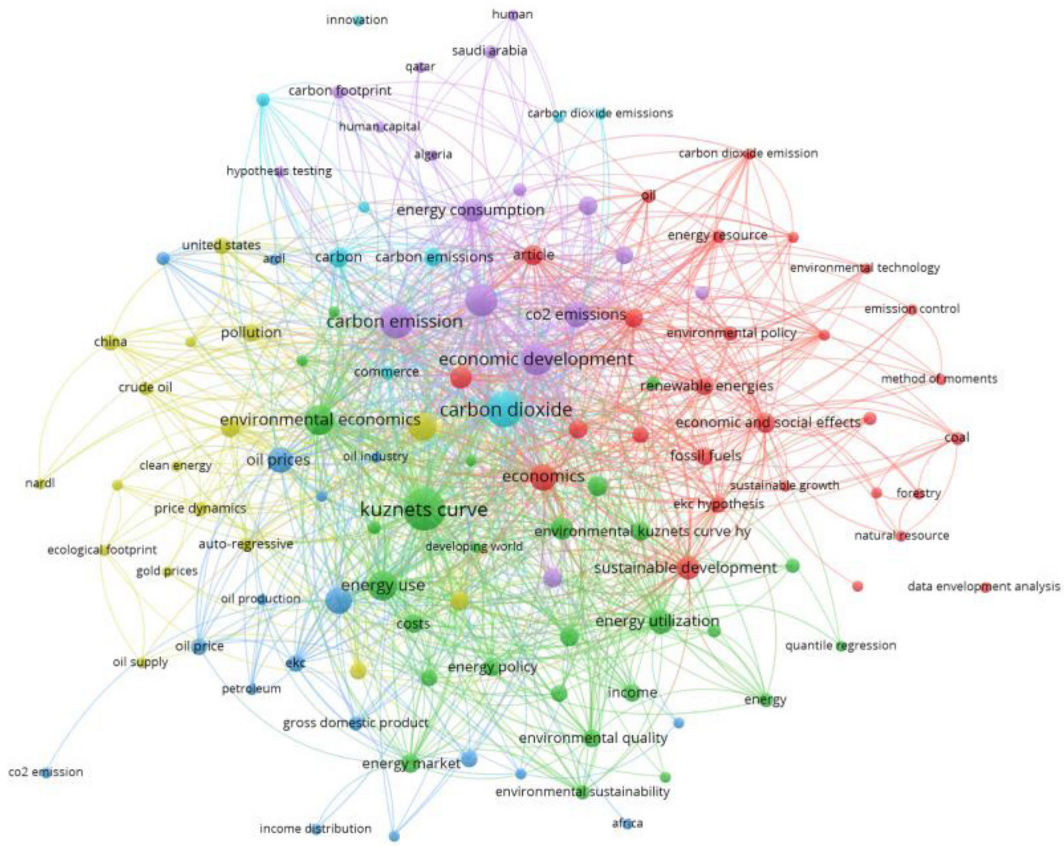

Figure 7. Analysis of co-occurring keywords

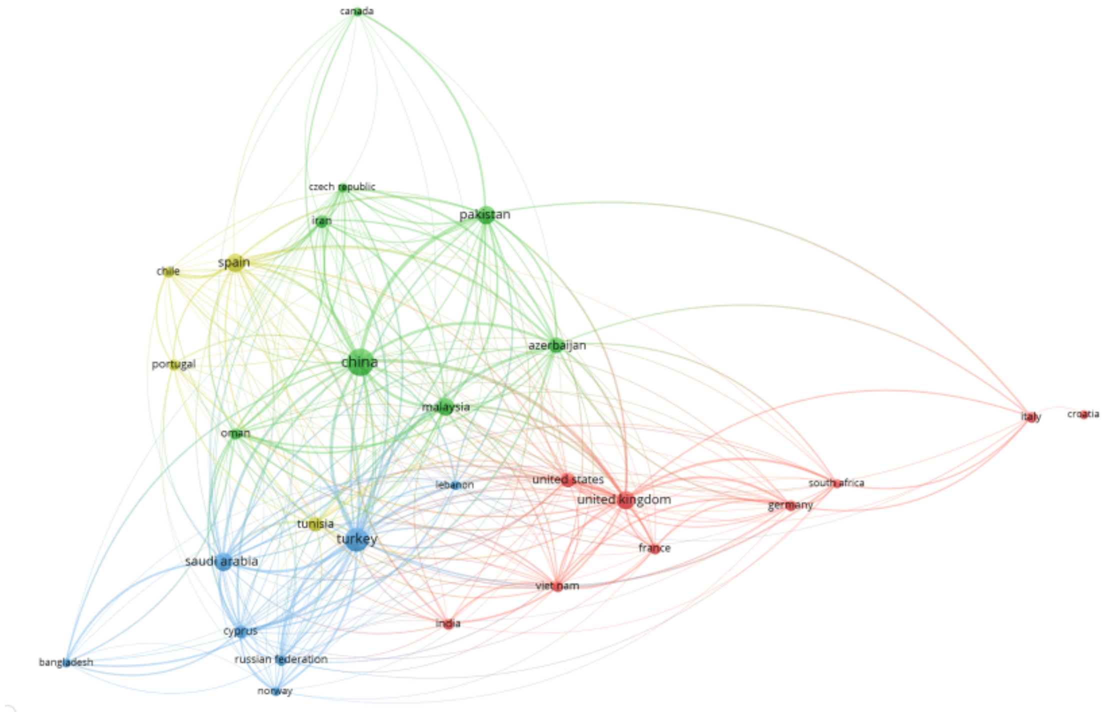

Figure 8. Country collaboration network analysis

co-citation activities among themselves as well as with other countries. The red color cluster represents the most dominant economies of the US, the UK, France, and Germany. The blue cluster points out Turkey, Cyprus, and Saudi Arabia. Moreover, the green nodal cluster represents the ties between China, Pakistan, Azerbaijan, and Malaysia. The analysis reveals distinct regional clusters, which also confirm the dominance of major economies in global research collaboration. Overall, this collaboration structure indicates that research on energy prices within the EKC framework is largely driven by a small group of leading economies. It shows strong regional clustering and limited but expanding cross-country linkages, shaping the global knowledge network to investigate the effect of energy prices in the EKC framework.

Overall, the science mapping analysis demonstrates a clear dual structure in the literature, where conceptual development is driven by an integrated energy–environment–economy framework, while collaboration patterns are concentrated among a limited number of leading economies. The findings indicate both thematic convergence and geographical concentration in the research production on the effect of energy prices on emissions in the EKC framework.

3.3. Thematic analysis and evolution

Figure 9 presents the thematic structure of the literature. The thematic map is based on centrality and the development degree of key research topics. "Kuznets curve", "carbon emissions", and "carbon dioxide" are found as the central ideas. The key research topics, such as "alternative energy", "renewable energy", and "CO2 emissions", are found as a motor theme, which are highly central and dense topics in the selected literature. Moreover, "sustainable development", "natural resources", and "carbon emissions" are basic themes. However, "China", "investments", and "climate change" are found as niche themes. On the whole, the analysis reflects that the literature showed centrality and density around environmental sustainability, energy transitions, and economic-environmental modeling. Overall, this thematic configuration indicates that energy prices are increasingly embedded within the core structure of EKC research. It also shapes both traditional emissions–growth linkages (EKC) and emerging sustainability-oriented themes such as renewable energy transition and policy-driven environmental change, instead of just focusing on energy prices.

Following the thematic map analysis, Figure 10 illustrates the temporal evolution of research

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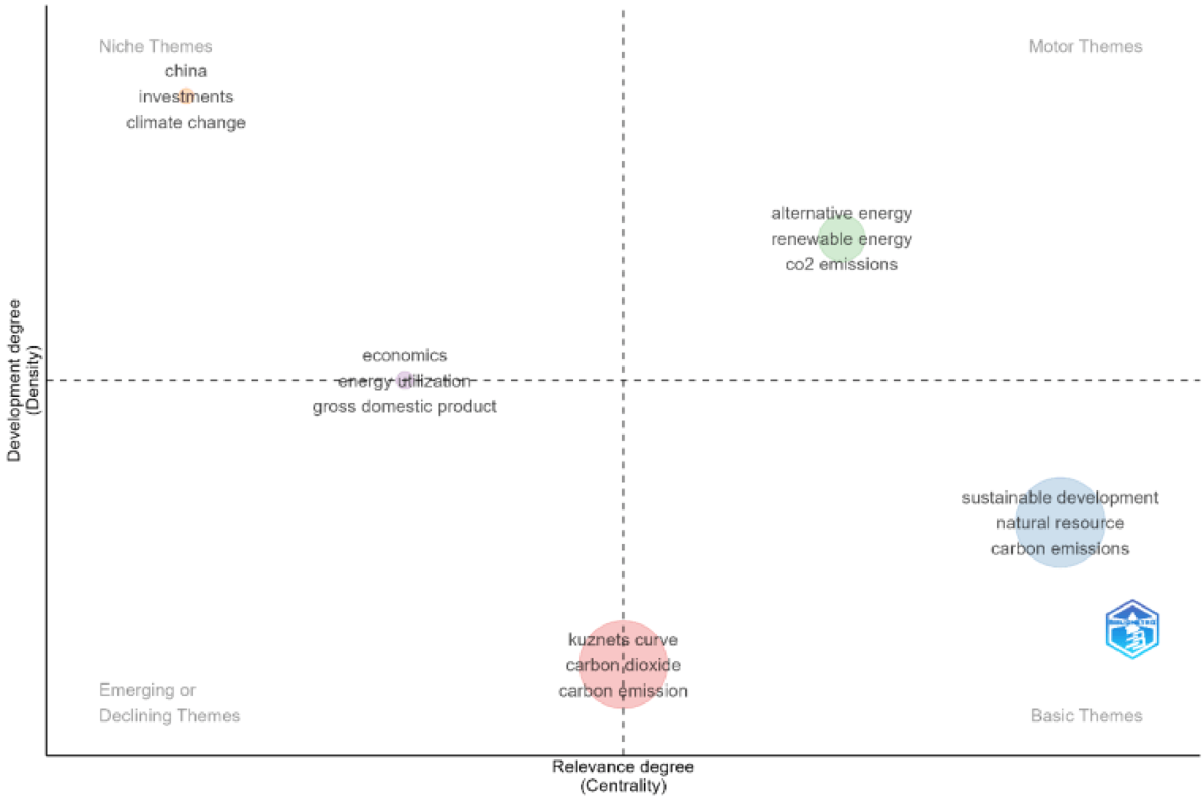

Figure 9. Thematic map

themes. It shows how rapidly specific keywords and topics appear in publications over time. The figure indicates that earlier research was primarily centered on "carbon dioxide emissions", "economic growth", "energy consumption," and "environmental Kuznets curve". Thus, the initial focus of the literature was on the empirical linkage between growth and environmental pollution indicators. However, the focus of the literature has changed to low emissions, carbon sequestration, and FDI, which is a more policy-relevant approach to reducing emissions. Overall, the literature has shifted from founda-

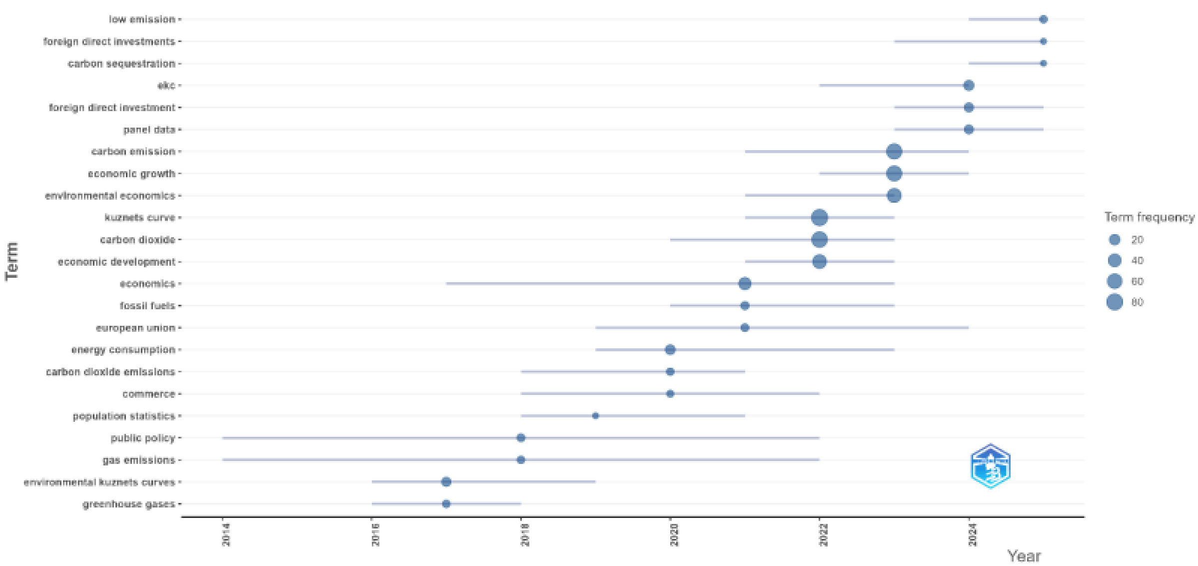

Figure 10. Trend topics

tional growth–emissions relationships toward policy-relevant and sustainability-driven research agendas within the EKC and energy price literature. This temporal evolution suggests that energy prices have become more prominent in shaping the shift from early growth–emissions relationships toward policy-oriented and sustainability-driven research agendas within the EKC framework.

Overall, the thematic structure and trend analyses indicate that the literature is no longer limited to testing the effect of energy prices in the conventional EKC hypothesis. Instead, recent studies increasingly focus on renewable energy transition, sustainability strategies, and policy-oriented approaches to emission reduction. This thematic evolution reflects growing scholarly interest in understanding how energy prices, environmental policies, and clean energy adoption can jointly contribute to sustainable economic development.

4. DISCUSSION

In the bibliometric analysis, the research on the role of energy prices in the EKC framework has been growing at an exponential rate since 2016, highlighting the increasing academic and policy relevance of the topic. This finding is consistent with the bibliometric analysis of Belgibayeva et al. (2025), who also found an exponential shift in the growth of the EKC literature after 2014. This topic is directly linked to the Paris Agreement, as controlling energy price fluctuations can support the carbon neutrality agenda, a market-based instrument for environmental protection. Moreover, the world has faced deep oil shocks since 2015, which motivates the research community to work on this topic. In addition, the recent geopolitical tensions have also introduced more volatility in energy production and prices, which motivates researchers to conduct research on this topic. However, during 1997–2014, the stagnant and minimal growth in publications suggests that, initially, researchers did not consider energy prices as a controlling or moderating factor within the EKC framework across different turning points.

The analysis of Bradford's Law suggests that most articles are published in environmental, sustainability, and policy-focused journals. This finding indicates that the environmental effects of energy prices are increasingly viewed as a sustainability and policy concern rather than solely an economic issue. The analysis of Lotka's Law confirms the dominance of low-frequency contributors. This pattern indicates that research on energy prices within the EKC framework remains dispersed through broad scholarly participation, although sustained contributions from specialized researchers remain relatively limited.

In the global citation analysis, Danish et al. (2020), Bednar-Friedl and Getzner (2003), Wang et al. (2022, 2023), Dogan et al. (2022), Nguyen et al. (2020), Alvarado et al. (2021), Pata and Işık (2021), Moomaw and Unruh (1997), and Balsalobre-Lorente et al. (2023) show a significant citation impact, with each document receiving more than 300 citations. Notably, this pattern is not observed in the local citation analysis, where the most cited documents by Al-Mulali and Ozturk (2016), Alvarado et al. (2021), and Balaguer and Cantavella-Jordá (2016) received fewer than 14 citations. This divergence between local and global citation patterns indicates that the energy–price–EKC literature receives less attention within its own research domain compared to the whole Scopus database.

The keyword co-occurrence and thematic map analyses reveal that the literature is centered around the core themes of "carbon dioxide," "Kuznets curve," and "economic growth", which are traditional components of EKC testing. However, "renewable energy" and "alternative energy" are also prominent and emerging terms in the recent literature, which have shaped the research from a traditional approach toward more solution-oriented and policy-based research. In addition, thematic map analysis also suggests that alternative energy, renewable energy, and CO2 emissions are emerging motor themes with high centrality and high density in the literature, which indicates scientific interest in investigating the role of renewable energy in supporting sustainability in times of highly fluctuating energy prices. In the bibliometric analysis, Ajmi et al. (2023) also identified that CO2 emissions, economic growth, and renewable energy are major motor themes in the EKC literature. Analysis of trend topics shows a steep rise in the co-occurrence of sustainable development with clean and alternative energy sources over time. In the bibliometric analysis, Belgibayeva et al. (2025) also identified renewable energy sources to achieve sustainable development.

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The synthesis of the empirical literature highlights that the role of energy prices in the EKC framework varies significantly as per the structural characteristics of economies. In energy-importing economies, the dominant inverse association between energy prices and emissions supports the cost-push hypothesis. Thus, higher energy prices promote energy conservation and efficiency improvements. This effect is particularly strong in advanced economies with the support of technological progress and policy frameworks, which facilitate a shift toward cleaner energy and strengthen EKC validation. However, the non-validation of the EKC in several energy-importing developing economies indicates that poor institutional quality and limited technological capacity may constrain the environmental benefits of higher energy prices. Moreover, the presence of N-shaped EKC patterns suggests that energy rebound effects may offset initial environmental gains at higher levels of income. The heterogeneous validity of the EKC is consistent with a prior review study emphasizing that EKC results are highly sensitive to structural heterogeneity across countries (Chaudhry & Reetu, 2025).

In contrast to energy-importing economies, the findings for energy-exporting economies reveal a predominantly positive relationship between energy prices and emissions, which reflects the dominant scale effect of rising resource rents. This finding suggests that higher energy prices may stimulate fossil-fuel-based economic activities, industrial expansion, and energy consumption in resource-dependent economies. These findings are consistent with the review study of Wiedenhofer et al. (2020), which corroborated that natural resources are responsible for environmental degradation. Consequently, this dynamic weakens support for the EKC hypothesis in many energy-exporting economies. Nevertheless, a few studies also validate the EKC hypothesis in high-income energy-exporting economies, reflecting their diversification efforts and renewable energy investment.

Similar mixed evidence is observed in global analyses. In global panel studies, most studies reported a negative impact of energy prices on emissions. It largely reflects the dominance of energy-importing economies in global samples. This finding suggests that higher energy prices may contribute to environmental improvement through the cost-push effect, which reduces energy demand and increases incentives for energy efficiency and a cleaner energy transition. However, support for the EKC is relatively weaker in global panels, which combine economies with different economic structures and development levels. This result also reflects the different methodological approaches, which are responsible for different EKC outcomes. Similar mixed evidence is also highlighted in prior review literature, where global and multi-country EKC syntheses emphasize that aggregated panel results are largely driven by methodological differences (Leal & Marques, 2022; Wiedenhofer et al., 2020).

In emerging and developing economies, the evidence remains more heterogeneous. Although most studies support a negative relationship between energy prices and emissions, a considerable number of studies also report a positive relationship. This result confirms that inefficient technologies, fossil fuel dependence, industrialization, weak regulatory systems, and energy-intensive production structures of developing economies lead to higher emissions. In this context, Belgibayeva et al. (2025) also emphasized the importance of energy structure in shaping environmental quality outcomes. Overall, most studies validate the inverted-U-shaped EKC. However, N-shaped patterns and non-validation of the EKC hypothesis are also observed in several developing economies, reflecting structural dependence on fossil fuels. Moreover, limited technological advancement continues to constrain sustainable environmental transition.

CONCLUSION

This study aims to synthesize the empirical literature on testing the environmental effects of energy prices within the EKC framework through bibliometric analysis and evidence-based literature synthesis. The findings of the bibliometric analysis show that scientific production has grown exponentially since 2016, with concentrated scholarly output and impact, a clear divergence between global and local citation influence, and a gradual shift toward renewable energy, sustainability, and policy-oriented research themes. The synthesis of the empirical literature reveals that the impact of energy prices on the EKC framework is heterogeneous and systematically depends on countries' levels of development and their energy trade structures.

The findings of the literature synthesis reveal that higher energy prices consistently reduce emissions and support the inverted-U-shaped EKC mostly in advance energy importing economies and emerging economies. However, the environmental outcomes of higher energy prices are found to be heterogeneous in energy-importing developing countries. Moreover, higher energy prices increase emissions in energy-exporting economies, which leads to invalidity or the N-shape of the EKC. However, the inverted-U-shaped EKC has also been validated in high-income energy-exporting economies, which reflects their recent renewable investments. In global panel studies, higher energy prices help reduce emissions, which aligns with the fact that most global economies are energy importers. However, these studies report mixed findings regarding the EKC, reflecting the heterogeneous economic structures and varying levels of development across countries worldwide.

These results provide insights for policymakers to trace context-specific policies. For instance, energy-importing economies should impose carbon taxes to accelerate the EKC downward stage. Moreover, energy-exporting economies should invest in renewable energy infrastructure in times of high energy prices to avoid N-shaped rebound effects.

AUTHOR CONTRIBUTIONS

Conceptualization: Haider Mahmood.
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Formal analysis: Haider Mahmood.
Funding acquisition: Haider Mahmood.
Investigation: Haider Mahmood, Syed Abdul Rehman Khan, Gowhar Meraj, Suraj Kumar Sing.
Methodology: Haider Mahmood, Syed Abdul Rehman Khan.
Project administration: Haider Mahmood.
Resources: Haider Mahmood.
Software: Haider Mahmood.
Supervision: Haider Mahmood.
Validation: Haider Mahmood, Gowhar Meraj, Suraj Kumar Sing.
Visualization: Haider Mahmood.
Writing – original draft: Haider Mahmood, Syed Abdul Rehman Khan, Gowhar Meraj, Suraj Kumar Sing.
Writing – review & editing: Haider Mahmood, Syed Abdul Rehman Khan, Gowhar Meraj, Suraj Kumar Sing.

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REFERENCES

1. Adebayo, T. S., Onifade, S., Alola, A. A., & Muoneke, O. B. (2022). Does it take international integration of natural resources to ascend the ladder of environmental quality in the newly industrialized countries? *Resources Policy, 76,* Article 102616. https://doi.org/10.1016/j.resourpol.2022.102616
2. Adedoyin, F. F., Nwulu, N., & Bekun, F. V. (2021). Environmental degradation, energy consumption and sustainable development: Accounting for the role of economic complexities with evidence from World Bank income clusters. *Business Strategy and the Environment, 30*(5), 2727-2740. https://doi.org/10.1002/bse.2774
3. Ajmi, A. N., Bekun, F. V., Gyamfi, B. A., & Meo, M. S. (2023). A bibliometric review analysis into environmental Kuznets curve phenomenon: A retrospect and future direction. *Heliyon, 9*(11), Article e21552. https://doi.org/10.1016/j.heliyon.2023.e21552
4. Aljadani, A., Toumi, H., Toumi, S., Hsini, M., & Jallali, B. (2021). Investigation of the N-shaped environmental Kuznets curve for COVID-19 mitigation in the KSA. *Environmental Science and Pollution Research, 28*(23), 29681-29700. https://doi.org/10.1007/s11356-021-12713-3
5. AlKhars, M. A., Alwahaishi, S., Fallatah, M. R., & Kayal, A. (2022). A literature review of the Environmental Kuznets Curve in GCC for 2010–2020. *Environmental and Sustainability Indicators, 14,* Article 100181. https://doi.org/10.1016/j.indic.2022.100181
6. Al-Mulali, U., & Ozturk, I. (2016). The investigation of environmental Kuznets curve hypothesis in the advanced economies: The role of energy prices. *Renewable and Sustainable Energy Reviews, 54,* 1622-1631. https://doi.org/10.1016/j.rser.2015.10.131
7. Alvarado, R., Tillaguango, B., Dagar, V., Ahmad, M., Işık, C., Méndez, P., & Toledo, E. (2021). Ecological footprint, economic complexity and natural resources rents in Latin America: Empirical evidence using quantile regressions. *Journal of Cleaner Production, 318,* Article 128585. https://doi.org/10.1016/j.jclepro.2021.128585
8. Balaguer, J., & Cantavella-Jordá, M. (2016). Estimating the Environmental Kuznets Curve for Spain by considering fuel oil prices (1874–2011). *Ecological Indicators, 60,* 853-859. https://doi.org/10.1016/j.ecolind.2015.08.006
9. Balsalobre-Lorente, D., Abbas, J., He, C., Pilar, L., & Shah, S. A. R. (2023). Tourism, urbanization and natural resources rents matter for environmental sustainability: The leading role of AI and ICT on sustainable development goals in the digital era. *Resources Policy, 82,* Article 103445. https://doi.org/10.1016/j.resourpol.2023.103445
10. Bashir, M. F., Bashir, M. A., Raza, S. A., Bilan, Y., & Vasa, L. (2024). Linking gold prices, fossil fuel costs and energy consumption to assess progress towards sustainable development goals in newly industrialized countries. *Geoscience Frontiers, 15*(3), Article 101755. https://doi.org/10.1016/j.gsf.2023.101755
11. Bednar-Friedl, B., & Getzner, M. (2003). Determinants of CO2 emissions in a small open economy. *Ecological Economics, 45*(1), 133-148. https://doi.org/10.1016/S0921-8009(03)00008-9
12. Belgibayeva, A., Artyukhov, A., Kubičková, V., Čukanová, M., Myroshnychenko, I., Ruzhytsky, I., & Lyeonov, S. (2025). Interrelationship between decentralization of energy sources and their renewability: A bibliometric analysis of research trends and thematic evolution. *Environmental Economics, 16*(3), 41-66. https://doi.org/10.21511/ee.16(3).2025.04
13. Bi, K., Masud, M. M., Akhtar, R., Md Noman, A. H., Zhao, Y., & Al-Mamun, A. (2025). Decoding climate change dynamics in Malaysia: Analysing energy, economic growth, foreign direct investment, and oil prices interplay. *Natural Resources Forum, 49*(2), 960-985. https://doi.org/10.1111/1477-8947.12421
14. Bilgili, F., & Barak, D. (2025). Examining substitution and income effects of oil prices through the Environmental Kuznets Curve framework. *Journal of Environmental Management, 379,* Article 124781. https://doi.org/10.1016/j.jenvman.2025.124781
15. Borozan, D. (2018). Efficiency of energy taxes and the validity of the residential electricity Environmental Kuznets Curve in the European Union. *Sustainability, 10*(7), Article 2464. https://doi.org/10.3390/su10072464
16. Borozan, D. (2019). Unveiling the heterogeneous effect of energy taxes and income on residential energy consumption. *Energy Policy, 129*(C), 13-22. https://doi.org/10.1016/j.enpol.2019.01.069
17. Boufateh, T. (2019). The environmental Kuznets curve by considering asymmetric oil price shocks: evidence from the top two. *Environmental Science and Pollution Research, 26*(1), 706-720. https://doi.org/10.1007/s11356-018-3641-3
18. Boufateh, T. (2021). The environmental issue facing asymmetric oil price shocks and renewable energy challenges: Evidence from Tunisia. *Environmental Science and Pollution Research, 28*(35), 48207-48221. https://doi.org/10.1007/s11356-021-14114-y
19. Bouznit, M., & Pablo-Romero, M. D. P. (2016). CO2 emission and economic growth in Algeria. *Energy Policy, 96,* 93-104. https://doi.org/10.1016/j.enpol.2016.05.036
20. Chaudhry, A., & Reetu, R. (2025). A systematic review of trade and environment linkages. *Discover Environment, 3*(1), Article 177. https://doi.org/10.1007/s44274-025-00368-7
21. Danish, Ulucak, R., & Khan, S. U.-D. (2020). Determinants of the ecological footprint: Role of re-

newable energy, natural resources, and urbanization. *Sustainable Cities and Society, 54,* Article 101996. https://doi.org/10.1016/j.scs.2019.101996

22. Delgado-Quirós, L., & Ortega, J. L. (2024). Completeness degree of publication metadata in eight free-access scholarly databases. *Quantitative Science Studies, 5*(1), 31-49. https://doi.org/10.1162/qss_a_00286

23. Dogan, B., Chu, L. K., Ghosh, S., Truong, H. H. D., & Balsalobre-Lorente, D. (2022). How environmental taxes and carbon emissions are related in the G7 economies? *Renewable Energy, 187,* 645-656. https://doi.org/10.1016/j.renene.2022.01.077

24. Ebaid, A., Lean, H. H., & Al-Mulali, U. (2022). Do oil price shocks matter for environmental degradation? Evidence of the Environmental Kuznets Curve in GCC countries. *Frontiers in Environmental Science, 10,* Article 860942. https://doi.org/10.3389/fenvs.2022.860942

25. Erdogan, S. (2024). On the impact of natural resources on environmental sustainability in African countries: A comparative approach based on the EKC and LCC hypotheses. *Resources Policy, 88,* Article 104492. https://doi.org/10.1016/j.resourpol.2023.104492

26. Erdogan, S., Okumus, I., & Guzel, A. E. (2020). Revisiting the Environmental Kuznets Curve hypothesis in OECD countries: The role of renewable, non-renewable energy, and oil prices. *Environmental Science and Pollution Research, 27*(19), 23655-23663. https://doi.org/10.1007/s11356-020-08520-x

27. Esmaeili, A., & Abdollahzadeh, N. (2009). Oil exploitation and the environmental Kuznets curve. *Energy Policy, 37*(1), 371-374. https://doi.org/10.1016/j.enpol.2008.08.022

28. Feng, C., Wang, M., Liu, G.-C., & Huang, J.-B. (2017). Green development performance and its influencing factors: A global perspective. *Journal of Cleaner Production, 144,* 323-333. https://doi.org/10.1016/j.jclepro.2017.01.005

29. Franklin, R. S., & Ruth, M. (2012). Growing up and cleaning up: The Environmental Kuznets Curve redux. *Applied Geography, 32*(1), 29-39. https://doi.org/10.1016/j.apgeog.2010.10.014

30. Franzen, A., & Mader, S. (2016). Predictors of national CO2 emissions: Do international commitments matter? *Climatic Change, 139*(3), 491-502. https://doi.org/10.1007/s10584-016-1795-x

31. Gbatu, A. P., Wang, Z., Wesseh, P. K. Jr., & Sesay, V. A. (2019). How do energy consumption, output, energy price, and population growth correlate with CO2 emissions in Liberia? *International Journal of Global Environmental Issues, 18*(3), 209-235. https://doi.org/10.1504/IJGENVI.2019.102776

32. Ginevičius, R., Lapinskiene, G., & Peleckis, K. (2017). The evolution of the environmental Kuznets curve concept: The review of the research. *Panoeconomicus, 64*(1), 93-112. https://doi.org/10.2298/PAN150423012G

33. Grossman, G. M., & Krueger, A. B. (1991). *Environmental impacts of the North American Free Trade Agreement* (NBER Working Paper 3914). https://doi.org/10.3386/w3914

34. Horbach, J., Rammer, C., & Rennings, K. (2012). Determinants of eco-innovations by type of environmental impact – The role of regulatory push/pull, technology push and market pull. *Ecological Economics, 78,* 112-122. https://doi.org/10.1016/j.ecolecon.2012.04.005

35. Husaini, D. H., Lean, H. H., & Ab-Rahim, R. (2021). The relationship between energy subsidies, oil prices, and CO2 emissions in selected Asian countries: A panel threshold analysis. *Australasian Journal of Environmental Management, 28*(4), 339-354. https://doi.org/10.1080/14486563.2021.1961620

36. Ike, G. N., Usman, O., Alola, A. A., & Sarkodie, S. A. (2020). Environmental quality effects of income, energy prices and trade: The role of REC in G-7 countries. *Science of the Total Environment, 721,* Article 137813. https://doi.org/10.1016/j.scitotenv.2020.137813

37. Issaoui, F., Bouchrika, A., Mohammed, E. Y., Jamee, A. F., & Mokni, K. (2024). Environmental dynamics in the case of Saudi Arabia: Is there a trade-off between growth constraints and ecological dimensions? *Journal of Energy and Development, 49*(1), 29-44. https://doi.org/10.56476/jed.v49i1.18

38. Javed, A., Rapposelli, A., Shah, M., & Javed, A. (2023). Nexus between energy consumption, foreign direct investment, oil prices, economic growth, and carbon emissions in Italy: Fresh evidence from autoregressive distributed lag and wavelet coherence approach. *Energies, 16*(16), Article 5885. https://doi.org/10.3390/en16165885

39. Jeon, H. (2022). CO2 emissions, renewable energy and economic growth in the US. *The Electricity Journal, 35*(7), Article 107170. https://doi.org/10.1016/j.tej.2022.107170

40. Joof, F., Samour, A., Ali, M., Tursoy, T., Haseeb, M., Hossain, M. E., & Kamal, M. (2023). Symmetric and asymmetric effects of gold, and oil price on environment: The role of clean energy in China. *Resources Policy, 81,* Article 103443. https://doi.org/10.1016/j.resourpol.2023.103443

41. Knorre, F., Wagner, M., & Grupe, M. (2021). Monitoring cointegrating polynomial regressions: Theory and application to the environmental Kuznets curves for carbon and sulfur dioxide emissions. *Econometrics, 9*(1), Article 0012. https://doi.org/10.3390/econometrics9010012

42. Koilo, V. (2019). Sustainability issues in maritime transport and main challenges of the shipping industry. *Environmental Economics, 10*(1), 48-65. https://doi.org/10.21511/ee.10(1).2019.04

43. Kuznets, S. (1955). Economic growth and income inequality. *American Economic Review, 45*(1), 1-28. Retrieved from https://www.jstor.org/stable/i304619

http://dx.doi.org/10.21511/ee.17(3).2026.05

44. Layachi, O. B. (2019). Effects of energy prices on environmental pollution: Testing environmental Kuznets curve for Algeria. *International Journal of Energy Economics and Policy, 9*(5), 401-408. https://doi.org/10.32479/ijeep.8312

45. Leal, P. H., & Marques, A. C. (2022). The evolution of the environmental Kuznets curve hypothesis assessment: A literature review under a critical analysis perspective. *Heliyon, 8*(11), Article e11521. https://doi.org/10.1016/j.heliyon.2022.e11521

46. Liberati, A., Altman, D. G., Tetzlaff, J., Mulrow, C., Gøtzsche, P. C., Ioannidis, J. P. A., Clarke, M., Devereaux, P. J., Kleijnen, J., & Moher, D. (2009). The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: Explanation and elaboration. *BMJ, 339,* Article b2700. https://doi.org/10.1136/bmj.b2700

47. Liobikienė, G. (2020). The revised approaches to income inequality impact on production-based and consumption-based carbon dioxide emissions: Literature review. *Environmental Science and Pollution Research, 27*(9), 8980-8990. https://doi.org/10.1007/s11356-020-08005-x

48. Mahajan, M., & Sah, A. N. (2025). CO2 emissions response to GDP and crude oil price shocks: Evidence from India and China using SVAR model. *Sustainable Futures, 9*(1), Article 100479. https://doi.org/10.1016/j.sftr.2025.100479

49. Mahmood, H. (2026). *Data: The role of energy prices in the environmental Kuznets curve framework: A systematic review (Version 1)* [Data set]. Mendeley Data. https://doi.org/10.17632/bkggyjzvvw.1

50. Mahmood, H., & Saqib, N. (2022). Oil rents, economic growth, and CO2 emissions in 13 OPEC member economies: Asymmetry analyses. *Frontiers in Environmental Science, 10,* Article 1025756. https://doi.org/10.3389/fenvs.2022.1025756

51. Mahmood, H., Furqan, M., Hassan, M. S., & Rej, S. (2023a). The Environmental Kuznets Curve (EKC) hypothesis in China: A review. *Sustainability, 15*(7), Article 6110. https://doi.org/10.3390/su15076110

52. Mahmood, H., Saqib, N., Adow, A. H., & Abbas, M. (2023b). Oil and natural gas rents and CO2 emissions nexus in MENA: Spatial analysis. *PeerJ, 11,* Article e15708. https://doi.org/10.7717/peerj.15708

53. Malik, M. Y., & Butt, H. D. (2025). Unequal energy footprints: Trade-driven asymmetries in consumption-based carbon emissions of the U.S. and China. *Energies, 18*(13), Article 3238. https://doi.org/10.3390/en18133238

54. Malik, M. Y., Latif, K., Khan, Z., Butt, H. D., Hussain, M., & Nadeem, M. A. (2020). Symmetric and asymmetric impact of oil price, FDI and economic growth on carbon emission in Pakistan: Evidence from ARDL and non-linear ARDL approach. *Science of the Total Environment, 726,* Article 138421. https://doi.org/10.1016/j.scitotenv.2020.138421

55. Moomaw, W. R., & Unruh, G. C. (1997). Are environmental Kuznets curves misleading us? The case of CO2 emissions. *Environment and Development Economics, 2*(4), 451-463. https://doi.org/10.1017/S1355770X97000247

56. Moutinho, V., Madaleno, M., & Elheddad, M. (2020). Determinants of the Environmental Kuznets Curve considering economic activity sector diversification in the OPEC countries. *Journal of Cleaner Production, 271,* Article 122642. https://doi.org/10.1016/j.jclepro.2020.122642

57. Mrabet, Z., AlSamara, M., & Jarallah, S. H. (2017). The impact of economic development on environmental degradation in Qatar. *Environmental and Ecological Statistics, 24*(1), 7-38. https://doi.org/10.1007/s10651-016-0359-6

58. Naimoglu, M. (2022). The impact of nuclear energy use, energy prices and energy imports on CO2 emissions: Evidence from energy importer emerging economies which use nuclear energy. *Journal of Cleaner Production, 373,* Article 133937. https://doi.org/10.1016/j.jclepro.2022.133937

59. Naimoglu, M. (2023). The effect of energy prices, energy losses, and renewable energy use on CO2 emissions in energy-importing developing economies in the presence of an environmental Kuznets curve. *Environmental Science and Pollution Research, 30*(20), 58755-58772. https://doi.org/10.1007/s11356-023-26656-4

60. Naveed, A., Ahmad, N., FatholahZadeh Aghdam, R., & Menegaki, A. N. (2022). What have we learned from Environmental Kuznets Curve hypothesis? A citation-based systematic literature review and content analysis. *Energy Strategy Reviews, 44,* Article 100946. https://doi.org/10.1016/j.esr.2022.100946

61. Nguea, S. M. (2023). Synthesizing the role of urbanization and oil prices in achieving carbon neutrality in Africa: Do financial crisis and renewable energy play a role? *Environmental Science and Pollution Research, 30*(58), 122322-122335. https://doi.org/10.1007/s11356-023-30834-9

62. Nguyen, T. T., Pham, T. A. T., & Tram, H. T. X. (2020). Role of information and communication technologies and innovation in driving carbon emissions and economic growth in selected G-20 countries. *Journal of Environmental Management, 261,* Article 110162. https://doi.org/10.1016/j.jenvman.2020.110162

63. Nugraha, A., Siregar, H., Fahmi, I., Asikin, Z., Indrawan, D., Harianto, H., & Aprilian, S. (2024). Identification of factors affecting net zero emission level in Indonesia. *International Journal of Energy Economics and Policy, 14*(5), 203-210. https://doi.org/10.32479/ijeep.16644

64. Onifade, S. T., Alola, A. A., Erdoğan, S., & Acet, H. (2021). Environmental aspect of energy transition and urbanization in the OPEC member states. *Environmental Science and Pollution Research, 28*(14), 17158-17169. https://doi.org/10.1007/s11356-020-12181-1

65. Ozcan, B., Esmaeili, P., Rafei, M., & Balsalobre-Lorente, D. (2024). Uncovering the drivers of CO2 emissions in the United States: The hidden spillover effects. *Journal of Environmental Management, 369,* Article 122332. https://doi.org/10.1016/j.jenvman.2024.122332

66. Ozkan, C., & Okay, N. (2024). Renewable energy, economic policy uncertainty and climate policy uncertainty: New evidence for Environmental Kuznets Curve from emerging and developed countries. *Sustainability, 16*(14), Article 6049. https://doi.org/10.3390/su16146049

67. Pablo-Romero, M. P., Cruz, L., & Barata, E. (2017a). Testing the transport energy-environmental Kuznets curve hypothesis in the EU27 countries. *Energy Economics, 62,* 257-269. https://doi.org/10.1016/j.eneco.2017.01.003

68. Pablo-Romero, M. P., Sánchez-Braza, A., & Sánchez-Rivas, J. (2017b). Relationships between hotel and restaurant electricity consumption and tourism in 11 European Union countries. *Sustainability, 9*(11), Article 2109. https://doi.org/10.3390/su9112109

69. Panayotou, T. (1993). *Green markets: The economics of sustainable development.* San Francisco: ICS Press Institute for Contemporary Studies. Retrieved from https://www.cabidigitallibrary.org/doi/full/10.5555/19931860649

70. Pata, U. K., & Işık, C. (2021). Determinants of the load capacity factor in China: A novel dynamic ARDL approach for ecological footprint accounting. *Resources Policy, 74,* Article 102313. https://doi.org/10.1016/j.resourpol.2021.102313

71. Pilar, L., Balsalobre-Lorente, D., Shah, S. A. R., & Abbas, N. (2025). Expose the linear and non-linear response of economic, digitalization and natural factors to environmental sustainability: An energy–environment dynamics in APEC economies. *Fluctuation and Noise Letters, 24*(5), Article 2540008. https://doi.org/10.1142/S0219477525400085

72. Qamruzzaman, M., Almulhim, A. A., & Aljughaiman, A. A. (2025). Nexus between uncertainty, innovation, and environmental sustainability in BRICS: An analysis under the Environmental Kuznets Curve (EKC) framework. *Frontiers in Environmental Science, 13,* Article 1570150. https://doi.org/10.3389/fenvs.2025.1570150

73. Ramakrishna, S., Ahmad, H., Qureshi, M. I., & Khan, N. (2020). Review on nexus between economic growth and environmental quality. *International Journal of Psychosocial Rehabilitation, 24*(1), 739-746. Retrieved from https://psychosocial.com/index.php/ijpr/article/view/239

74. Richmond, A. K., & Kaufmann, R. K. (2006). Energy prices and turning points: The relationship between income and energy use/carbon emissions. *The Energy Journal, 27*(4), 157-180. https://doi.org/10.5547/ISSN0195-6574-EJ-Vol27-No4-7

75. Rodriguez, M., Pena-Boquete, Y., & Pardo-Fernández, J. C. (2016). Revisiting Environmental Kuznets Curves through the energy price lens. *Energy Policy, 95,* 32-41. https://doi.org/10.1016/j.enpol.2016.04.038

76. Saboori, B., Al-Mulali, U., Bin Baba, M., & Mohammed, A. H. (2016). Oil-induced Environmental Kuznets Curve in organization of petroleum exporting countries (OPEC). *International Journal of Global Environmental Issues, 15*(1/2), 29-42. https://doi.org/10.1080/15435075.2014.961468

77. Sadik-Zada, E. R., & Loewenstein, W. (2020). Drivers of CO2-emissions in fossil fuel abundant settings: (Pooled) mean group and nonparametric panel analyses. *Energies, 15*(13), Article 3956. https://doi.org/10.3390/en13153956

78. Saini, N., & Singhania, M. (2019). Environmental impact of economic growth, emission and FDI: Systematic review of reviews. *Qualitative Research in Financial Markets, 11*(1), 81-134. https://doi.org/10.1108/QRFM-09-2017-0087

79. Sarkodie, S. A., & Strezov, V. (2019). A review on Environmental Kuznets Curve hypothesis using bibliometric and meta-analysis. *Science of the Total Environment, 649,* 128-145. https://doi.org/10.1016/j.scitotenv.2018.08.276

80. Serino, M. N. V. (2022). Energy security through diversification of non-hydro renewable energy sources in developing countries. *Energy & Environment, 33*(3), 546-552. https://doi.org/10.1177/0958305X211013452

81. Shahbaz, M., Patel, N., Du, A. M., & Ahmad, S. (2024). From black to green: Quantifying the impact of economic growth, resource management, and green technologies on CO2 emissions. *Journal of Environmental Management, 360,* Article 121091. https://doi.org/10.1016/j.jenvman.2024.121091

82. Shahbaz, M., Solarin, S. A., Hammoudeh, S., & Shahzad, S. J. (2017). Bounds testing approach to analyzing the environment Kuznets curve hypothesis with structural breaks: The role of biomass energy consumption in the United States. *Energy Economics, 68,* 548-565. https://doi.org/10.1016/j.eneco.2017.10.004

83. Shahnazi, R., Jamshidi, N., & Shafiei, M. (2024). Investigating the effects of crony capitalism on CO2 emissions. *Journal of Cleaner Production, 438,* Article 140833. https://doi.org/10.1016/j.jclepro.2024.140833

84. Sun, J., Zhou, T., & Wang, D. (2023). Effects of urbanisation on PM2.5 concentrations: A systematic review and meta-analysis. *Science of the Total Environment, 900,* Article 166493. https://doi.org/10.1016/j.scitotenv.2023.166493

85. Tabash, M. I., Farooq, U., El-Refae, G. A., & Qasim, A. (2023). Exploring the carbon footprints of economic growth, foreign investment, energy dependency and financial development: Does EKC work in GCC region? *Management of Environmental Quality: An International Journal, 34*(2), 273-289. https://doi.org/10.1108/MEQ-05-2022-0137

86. Tokpah, J. T., Saliminezhad, A., & Ozdeser, H. (2024). CO2 emissions-economic growth nexus: Validity of EKC in oil-exporting and oil-importing countries. *OPEC Energy Review, 48*(3), 151-166. https://doi.org/10.1111/opec.12301

87. Tran, N. D., Sahu, N. C., & Kumar, P. (2023). Income, coal consumption, and the environmental Kuznets curve in Vietnam. *Environmental Science and Pollution Research, 30*(20), 58200-58212. https://doi.org/10.1007/s11356-023-26682-2

88. Udemba, E. N., & Yalçıntaş, S. (2023). Economic and environmental implications of resource rent: A dual analysis of Venezuela's sustainability. *International Social Science Journal, 73*(247), 215-231. https://doi.org/10.1111/issj.12378

89. Wang, Q., Wang, X., & Li, R. (2022). Does urbanization redefine the environmental Kuznets curve? An empirical analysis of 134 countries. *Sustainable Cities and Society, 76,* Article 103382. https://doi.org/10.1016/j.scs.2021.103382

90. Wang, Q., Zhang, F., & Li, R. (2023). Revisiting the environmental Kuznets curve hypothesis in 208 counties: The roles of trade openness, human capital, renewable energy and natural resource rent. *Environmental Research, 216*, Article 114637. https://doi.org/10.1016/j.envres.2022.114637

91. Wei, P., Li, Y., Ren, X., & Duan, K. (2022). Crude oil price uncertainty and corporate carbon emissions. *Environmental Science and Pollution Research, 29*(2), 2385-2400. https://doi.org/10.1007/s11356-021-15837-8

92. Wiedenhofer, D., Virág, D., Kalt, G., Plank, B., Streeck, J., Pichler, M., Mayer, A., Krausmann, F., Brockway, P., Schaffartzik, A., Fishman, T., Hausknost, D., Leon-Gruchalski, B., Sousa, T., Creutzig, F., & Haberl, H. (2020). A systematic review of the evidence on decoupling of GDP, resource use and GHG emissions, part I: Bibliometric and conceptual mapping. *Environmental Research Letters, 15*(6), Article 063002. https://doi.org/10.1088/1748-9326/ab8429

93. Xu, T., Feng, C., Guluzada, E., & Chen, C. (2024). Evaluating the advancement of sustainable development objectives in recently industrialized nations by tying gold prices, fossil fuel prices, and energy use. *Energy Strategy Reviews, 56,* Article 101575. https://doi.org/10.1016/j.esr.2024.101575

94. Zaghdoudi, T. (2017). Oil prices, renewable energy, CO2 emissions, and economic growth in OECD countries. *Economics Bulletin, 37*(3), 1844-1850. Retrieved from https://ideas.repec.org/a/ebl/ecbull/eb-17-00582.html

95. Zhang, J., Yu, Q., Zheng, F., Long, C., Lu, Z., & Duan, Z. (2016). Comparing keywords plus of WOS and author keywords: A case study of patient adherence research. *Journal of the Association for Information Science and Technology, 67*(4), 967-972. https://doi.org/10.1002/asi.23437

96. Zhao, F., Zhang, Y., Alharthi, M., & Zafar, M. W. (2022). Environmental sustainability in developing countries: Understanding the criticality of financial inclusion and globalization. *Sustainable Development, 30*(6), 1823-1837. https://doi.org/10.1002/sd.2350