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DETERMINANTS OF ENERGY INTENSITY IN EMERGING ECONOMIES: A COMPREHENSIVE REVIEW OF THE LAST THREE DECADES

Abstract

Energy intensity is a critical indicator of a country's energy efficiency and environmental sustainability. This review article delves into the determinants of energy intensity in emerging economies, spanning the past 30 years of research accessed from Web of Science. Leveraging advanced tools such as RStudio and Biblioshiny, we analyze a rich quantity of scholarly publications to offer a comprehensive synthesis of the field's progress. The review begins by providing a conceptual framework for understanding energy intensity and its relevance in the context of emerging economies. We then investigate the key determinants that have been explored in the literature, including technological advancements, industrial structure, economic growth, urbanization, financial development, trade and environmental regulations. Our analyses highlight the evolving trends and research gaps in each determinant, shedding light on the dynamic nature of energy intensity in emerging economies. Furthermore, we employ data visualization techniques to present a bird's-eye view of the research landscape, showcasing the geographical distribution of studies, prominent authors, and key journals in the field. Through a systematic assessment of methodological approaches, we evaluate the robustness of the existing literature, pinpointing areas where methodological improvements and novel data sources can enhance future research. It offers valuable insights for policymakers, researchers, and practitioners striving to develop effective strategies for reducing energy intensity and promoting green growth. As emerging economies continue to play a pivotal role in the global energy landscape, understanding and addressing the determinants of energy intensity remains crucial for a sustainable future.

Keywords: *Energy intensity; environmental sustainability; Sustainable Development Goals; emerging economies*

Introduction

Energy intensity is considered an integral part of environmental sustainability and green growth because it is a direct determinant of resource efficiency, economic development, and environmental well-being. In terms of SDGs, measuring and reducing energy intensity is important because it is directly related to several goals including affordable and clean energy (SDG 7), industrialization and innovation (SDG 9), and climate action (SDG 13). High energy intensity is a sign of inefficient resource utilization that can slow down the progress towards sustainable development goals. In addition, energy intensity is a key dimension of environmental sustainability since it raises high

greenhouse gas emissions, air pollution, and resource consumption worsening climate change and environmental issues. Analyzing determinants of energy intensity and factors behind energy intensity patterns leads to identification of key points. This information can be used to develop targeted interventions, which promote energy efficiency, renewable energy adoption, and green practices. Such information is very important for creating appropriate plans, investments and innovations to be environmentally friendly, low-carbon, and long-lasting for the sake of the current and future people.

Due to the growing relevance of sustainable development and the need to counteract climate change, the factors that determine energy intensity in emerging economies have received a lot of attention in recent years. One of the most important measures of energy efficiency is energy intensity, which is the quantity of energy used to generate one unit of economic output. Given their outsized impact on global energy consumption and greenhouse gas emissions, emerging economies' energy intensity factors bear serious study (Wang et al., 2019). Exploring the factors that affect the energy intensity of emerging economies is crucial because of their distinctive characteristics, such as fast industrialization, urbanization, and technological breakthroughs (Cantore et al., 2016). This study aims to investigate the determinants of energy intensity in the emerging economies from various angles. In this regard, this study find answers to following research questions:

Q_1: What are the main factors of energy intensity in emerging countries and what can be done to tackle them?

Q_2: What is the most prevalent research topics and trends in the papers about the determinants of energy intensity of emerging economies?

Q_3: What major emerging economies have been the topic of most academic discussions about energy intensity determinants, and how did this coverage change along the way?

Q_4: Which authors, publications and sources are the most important and what do they say about energy intensity determinants in developing economies?

Q_5: Through interdisciplinary collaboration and research methodology, how has the study of energy intensity determinants for emerging economies been shaped?

Q_6: What are the growing gaps and domains for future research that the bibliometric analysis on the energy intensity determinants in emerging economies captures?

The idea of emerging markets is becoming increasingly commonplace in a variety of disciplines, including international politics, economics, and finance, as a result of the expansion of economic globalization. Since the global financial crisis of 2008, emerging market countries like Brazil, Russia, India, China and South Africa (together referred to as BRICS) have been viewed as the key impetus of the world economy's growth (Sun et al., 2022), thereby popularizing studies in these fields. All nations with emerging market economies are considered to be developing nations. These nations are going through a period of rapid industrialization and urbanization, in addition to a surge in energy consumption. In the meantime, there is a connection of cause and effect between issues pertaining to energy and the development of the financial sector (Durusu-Ciftci et al., 2020), the agricultural market, economic expansion, and the natural environment (Ioannou et al., 2018; Zafeiriou et al., 2018). As a result, increasing energy efficiency in emerging market economies is an essential component of social and economic development that can be sustained over time.

The results of this study will add to what is already known about the factors that influence energy intensity in emerging economies. Policymakers will find the study's practical implications especially useful because they can direct the development of efficient energy policies and actions. The research findings will also make it easier for stakeholders to share information and work together, encouraging the adoption of sustainable energy practices and assisting emerging economies in making the transition to a low-carbon future. This study helps shed light on the factors that are influencing energy intensity levels in emerging economies. Understanding these factors better can aid in the creation of long-term sustainable energy strategies, boost international efforts to slow climate change, and help emerging economies grow economically and socially. Industrial structure with a sizable manufacturing component, the state of technological advancement and the rate of adoption of energy-efficient technologies, government energy policies and regulations, infrastructure growth, energy subsidies and pricing, international cooperation and technology transfer, and environmental concerns all play a role in determining the energy intensity of an emerging economy (Q. WangSu et al., 2019). Promoting a shift towards a service-oriented economy, investing in R&D, implementing energy efficiency standards, improving infrastructure, reforming

energy pricing and subsidies, engaging in international collaborations, and prioritizing environmental sustainability are all examples of what can be done to lower energy intensity (Hui Zhang & Fan, 2019; Zhao et al., 2018).

Although there is a plethora of literature on the topics of energy intensity and emerging economies, there are still a number of knowledge gaps that must be filled. Sector-specific research, long-term analysis to understand changes over time, examination of technological diffusion and spillover effects, incorporation of socio-economic aspects, evaluation of policy efficacy, and improvements in data availability and quality are all areas where more work is needed (Panoutsou et al., 2021; Zafeiriou et al., 2018). Closing these knowledge gaps would help researchers gain a more holistic perspective on the dynamics at play in emerging economies as they relate to energy intensity. In order to boost energy efficiency, cut down on energy intensity, and advance sustainable development in these nations, this information can guide the creation of tailored policies, technologies, and strategies.

Policymakers give considerable attention to studies concerned with energy intensity, as they are effective in making policy development and environmental strategies. Determining components of energy-intensity requirements is especially important for the design of efficient energy policies in emerging economy, one of the key instruments in the rapid economic growth with environmental sustainability. Effective energy management provides the base to maintain the economic advancement with minimal energy wastage thus setting and achieving objectives like carbon emission reduction. Furthermore, the participation of many countries in international agreements such as the Paris Agreement, obliging them to lower their carbon footprint, makes research on energy intensity very important in order to comply with the requirements of the agreement and monitor the progress. Many stakeholders are interested in what research criteria mapping researchers chose and applied in their studies. Through the mapped data, the scientific researchers track developments, shortfalls, and researchable topics to remain current, and fill those researchable gaps. Governmental bodies utilize mapped research to establish policies and to implement plans for the establishment of programs while industries and other high-energy-consuming entities can innovate and enhance their processes to use reduced energy and costs. The environmental

NGOs and international organizations, including the UN or the World Bank, also rely on these statistics to champion impactful policies, educate the public and ultimately guide global progress on energy efficiency strategies.

Energy intensity is a key metric for researchers in the fields of energy economics and environmental sustainability. A country's economic energy efficiency can be better understood and problem areas in energy use can be better pinpointed with knowledge of energy intensity (Kumar et al., 2023). A distinctive aspect of emerging economies is their high rates of economic growth and industrialisation. The efficiency and viability of this expansion can be evaluated in large part by measuring its energy intensity. A high energy intensity may point to inefficient use of resources and pose threats to the economy over the long term (Bhat et al., 2018). Due to their increasing energy needs and reliance on imports, emerging economies frequently confront threats to their energy security. Opportunities for lessening reliance on a single energy source, increasing diversification of energy sources, and bolstering energy security can be found through an examination of energy intensity (Haider & Mishra, 2021).

Environmental sustainability is intrinsically tied to energy intensity. Increased greenhouse gas emissions and other environmental pollutants may result from the higher energy intensity of emerging economies. The environmental effects of rapid economic growth can be better understood and countered by studying energy intensity, which may be learned from such an analysis (Hongyan Zhang et al., 2022). Energy resources in emerging economies are generally limited. The availability and sustainability of energy sources are guaranteed when measures are taken to reduce energy waste by analyzing energy intensity (S. Wang et al., 2021). A country's ability to compete internationally may be harmed by the high energy intensity typical of emerging economies. Higher production costs could reduce the competitiveness of energy-intensive sectors. Industries may boost their production, cut expenses, and strengthen their competitive standing by analyzing and resolving their energy intensity (S. Wang et al., 2021). Policymakers can use the results of energy intensity analyses to create workable energy policies and plans. Policymakers may promote energy efficiency, lower costs, and increase economic competitiveness by better understanding the causes and

determinants of energy intensity and developing customized actions, regulations, and incentives (Pradhan et al., 2021).

The targets for energy intensity are in line with those for sustainable development. For emerging economies, lowering their energy intensity is a key to achieving economic growth with little impact on finite resources and the environment. Reducing poverty, raising living standards, and making the shift to a low-carbon economy are all aided by sustainable energy practices (Chalvatzis et al., 2019). Policymakers, academics, and stakeholders can learn a great deal about energy efficiency, resource management, and environmental sustainability by analyzing the energy intensity of emerging economies. This knowledge is crucial for guiding policymaking, inspiring creativity, and promoting long-term growth in these fast-paced economies (Pradhan et al., 2022).

2. Determinants of Energy Intensity: Literature Review

Energy intensity, or the volume of energy used to generate one dollar of economic production, can be affected by a number of external variables. Different industries, economies, and settings each have their own unique sets of these elements (Shi & Li, 2020). The following are some of the most influential determinants of energy intensity that have been reported by existing literature:

2.1 Technology Innovation and Energy Intensity

Reducing energy intensity is greatly aided by technological progress and developments in energy-efficient technology (Dasgupta & Roy, 2015). Ma and Stern (2008) use the logarithmic mean Divisia index to investigate at how energy use per unit has changed since 1980. The authors also find that technology change is the most important reason why energy intensity has declined. Energy-efficient technology, equipment, and processes can increase output while decreasing input energy needs. Energy intensity can be affected by the cost of various forms of energy. A decrease in energy intensity can be achieved by the adoption of energy-saving measures and the funding of energy-efficient technology in response to increases in the cost of energy

(Soni et al., 2017). Furthermore, Kouakou & Soro (2022) also investigated at the factors that influence energy intensity in West African nations. According to their research, certain industries' energy intensity can rise as a result of gross fixed capital formation and infrastructural expansion. As a result, it's clear that developing nations may need to spend more in energy-efficient technology and infrastructure if they intend on reducing their energy intensity.

The links between technology innovation and energy intensity are even more intricate and dynamic, because of the energy rebound effect, which complicates this relationship, as improved efficiency may paradoxically result in increased energy consumption. Therefore, even while technological innovation has the potential to reduce energy intensity at first, the rebound effect emphasizes how crucial it is to take into account a wider range of socioeconomic conditions and behaviors when evaluating the overall impact on technology innovations on energy consumption. According to the Fan et al. (2016), the rebound effect restricts the ability of technological advancements to reduce energy intensity, which emphasizes the significance of managing rebound effects through focused policies. In contrast to traditional assessments of the rebound effect, Xing et al. (2020) use an optimization approach to estimate potential reductions in energy intensity in four Asian countries (China, India, Japan, and Korea) between 1973 and 2017. The Brockway et al. (2021) study finds that many of the mechanisms causing rebounds are missed by the current global energy models. Current research on the rebound effect indicates that global energy scenarios may underestimate the rate of growth in global energy demand in the future, and the phenomenon requires further research.

2.2 Industrialization and Energy Intensity

The overall energy intensity can be affected by the structure and composition of an economy, which includes the size and energy intensity of various sectors. For instance, manufacturing and heavy industries have a higher energy intensity than service-based sectors since they use more energy in their operations (Albrizio et al., 2017). Moreover, Atalla, T. and Bean, P. (2017) argued that rapid development in industry sectors should be accountable for China's high energy intensity, while rising energy prices contribute to reducing energy intensity.

2.3 Infrastructure and Energy Intensity

Energy intensity can be influenced by the standard and effectiveness of infrastructure, which includes roads, buildings, and city planning. Infrastructure that is both well-designed and energy-efficient, along with effective public transit and eco-friendly city planning, can all help bring down energy intensity (Rajbhandari & Zhang, 2018). Similarly, climatic and geographical factors are also important determinants. Climate extremes may increase energy intensity because of the increased need for heating and cooling. Energy intensity can be influenced by geographical characteristics such as terrain and distance to energy sources, which in turn affects the cost of distributing energy and transporting it (Xu & Wang, 2018).

2.4 Energy Consumption and Energy Intensity

The accessibility and diversity of these sources of energy can modify the energy intensity. Energy intensity may be higher in economies that rely primarily on fossil fuels than in countries that have a more varied energy mix that includes renewable energy sources (Q. WangJiang et al., 2019). The availability of stable and low-cost energy sources is also a factor in overall energy intensity.

2.5 Regulations and Energy Intensity

The energy intensity of a country can be greatly affected by its policies and regulations. Energy intensity decrease can be driven by energy efficiency regulations, renewable energy adoption incentives, and energy conservation initiatives. On the other hand, less stringent rules or no energy efficiency standards at all could result in increased energy intensity (Özkara & Atak, 2015). Even though previous studies have determined that the consumption of energy is the primary contributor to air pollution and that energy-saving technologies have the potential to significantly reduce energy intensity and haze pollution (Chen, Gao, Li, & Song, 2019; Lin & Liu, 2016), concerns remain as to whether or not urban air pollution, subject to a predetermined level of environmental regulation, may actually cause a decrease in energy intensity.

2.6 GDP and Energy Intensity

The energy intensity is affected by the economic activity and structure in general. When economic output rises, so does the need for energy, which can increase energy intensity. Energy intensity can be reduced, however, by making structural changes to the economy, such as moving away from energy-intensive industries and toward service-oriented ones (Özkara & Atak, 2015). Wu et al. (2022) examine emerging country energy intensity and economic growth. The study shows that energy intensity insignificant affects sustainable economic growth. This means economies must emphasize energy efficiency and lower energy intensity for sustainable growth. The findings imply that green financing and eco-innovation can help emerging economies reduce energy intensity and improve energy efficiency. Mainly developed countries are seeing a decrease in energy intensity as their economies expand, while emerging countries are seeing an increase (Nilsson, L. J. 1993). The fundamental reason for this is that the energy consumption growth rate in developed countries is lower than the GDP growth rate. This also means that for every 1% increase in economic growth, more than 1% more energy is needed in developing countries, while less energy is needed in developed economies.

2.7 Financial Development and Energy Intensity

Canh et al (2020) compared the energy intensity of 29 HIEs, 21 UMEs, and 31 LMEs across an array of income levels to determine the multifaceted influence of financial development on consumption and production energy intensity. The authors revealed that a decline in production energy intensity in HIEs results from financial development. The results of an investigation by Adom et al (2020) into the connection between financial development and energy intensity in Ghana demonstrated that financial development causes a reduction in energy intensity. Using the Panel Smooth Transition model, Rakpho et al (2021) explored the influence that nations in Asia-16's level of financial development had on their level of energy security. The researchers revealed that increased financial development leads to a reduction in the energy inefficiency of the economy.

2.8 Foreign Direct Investment and Energy intensity

Foreign direct investment (FDI) has the potential to increase energy efficiency and decrease energy intensity by introducing cutting-edge technologies and managerial practices. Mielnik and Goldemberg (2002) found that when FDI grew in 20 different developing nations, the energy intensity of their economies decreased because of the spread of new technology. Despite the fact that Elliott et al. (2013) found a significant relationship between FDI and energy intensity, the effect varies by location due to variations in areas' endurance to absorb and reap the benefits of environmental consequences.

2.9 Trade and Energy Intensity

Cole (2006) found that trade openness and energy use can have either a positive or a negative relationship, depending on the structure of trade; in particular, this is affected by countries being net exporters or importers of energy-intensive products. This intersection leads each country to shift resources into sectors that make the most efficient use of lucrative resources in order to decrease energy intensity.

Moreover, Rafiq et al. (2016) investigate the relationship between urbanization, openness, emissions, and energy intensity in more urbanized emerging economies. The results show that urbanization and openness are significantly linked to higher energy intensity. This means that as developing economies become more urban and open to trade and investment, their energy intensity tends to rise. This could be due to the higher energy needs of cities and the energy-intensive nature of some businesses that are attracted by openness.

2.10 Energy Prices

Energy intensity can be affected by energy prices such as those of fossil fuels, electricity, and renewables. Businesses and people may be encouraged to cut back on their energy consumption by high energy prices. Cornillie and Fankhauser (2004) investigated the energy intensity of transition economies. The authors revealed that the price of energy and how far the process of reorganizing entities has come are important factors for making better use of energy.

3 Methodology

The key purpose of this study is typically to synthesize existing research findings rather than generate new empirical evidence. This bibliometric study utilized the March 2023 edition of the Web of Science (WoS) Core Collection database for its papers. WoS, a Thomson Reuters company, provides bibliometricians with an abundance of data and the ability to construct statistics via bibliometric measures. After rigorous selection procedures and impartial evaluation processes, WoS includes the most credible and well-known scholarly publications in a number of disciplines. We included three decades in this study because these thirty years reveal most of economic trends, literature and important decision regarding energy transitions. The search phrases *determinants of energy intensity in emerging economics* were used to ensure that sufficient and relevant publications were found. Literature search results are extracted by joining the proposed search phrases with *OR* logical operations and asterisks. The literature review covers the years 1993 to 2023 and includes all studies on the subject of energy intensity in the pursuit of emerging economic goals. Journal articles are isolated from the other document types using an additional filter. There should be a rigorous, high-quality peer review process where journal papers are rated based on their originality. The WoS Core Collection database had a total of 3,918 articles.

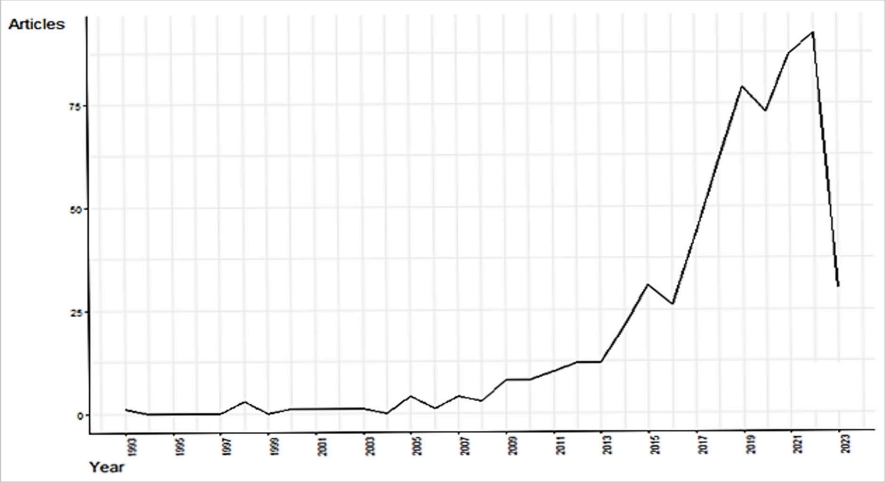
3.1 Annual Scientific Production

The increasing number of papers on energy intensity in emerging economies demonstrates the growing importance of this topic in academic research and the awareness of its relevance for sustainable development, energy policy, and economic growth in emerging economies.

As per the above graph, from 1993 through 2023, the number of publications covering emerging economies' *energy intensity* is depicted graphically. It's evidence of the growing attention and study of this topic over time. Few papers were published in the years 1993, 1998, and 2000, and none were published at all between 1993 and 1999. The number of articles published, however, began to rise steadily after 2005. Research output increased dramatically between 2014 and 2022, with the number of published articles rising each year. In 2022,

92 articles were published, with 2021 coming in a close second with 87. In comparison to the previous year, there were fewer publications published in 2023. It should be noted, however, that the information provided only goes up to June 2023, and that additional articles may be released later in the year.

Figure 1. *Annual Scientific Production*



Source: Authors' work

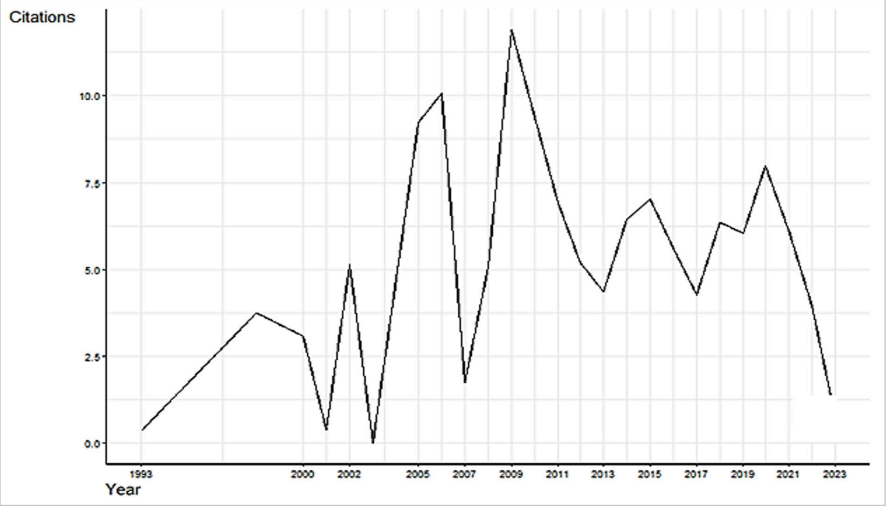
3.2 Average Citations per Year

Considerations related to energy intensity in emerging economies that may influence citation patterns should be taken into account while interpreting the graph. These include the quality and significance of the research published in each year, the subject or discipline of the articles, and other contextual considerations.

As per the graph, the effect of research grows with time, as measured by the average number of citations received by publications published in each year. The y-axis shows the Mean Total Citations per Year, which gives an idea of how much focus and recognition each year's articles have received on average. Some trends are visible in the graph: There is some periodic fluctuation in the Mean Annual Total Citations. The average number of citations published each year was low and varied from 1993 to 1998. The average number of citations received each year has been rising since 2005, pointing

to the increasing significance of citations. The graph shows ups and downs in the typical number of citations. Increases in average citation counts can be seen in 2009, 2010, 2014, 2015, 2018, and 2020, for instance. However, there are troughs or low points in some years. The graph shows that the impact of citations varies greatly throughout the years. The average number of citations for some years is higher than for others, indicating that the works produced in those years have been more frequently reviewed and cited. On the other hand, lower average citation counts in some years indicate less citation impact overall.

Figure 2. *Average Citations per Year*

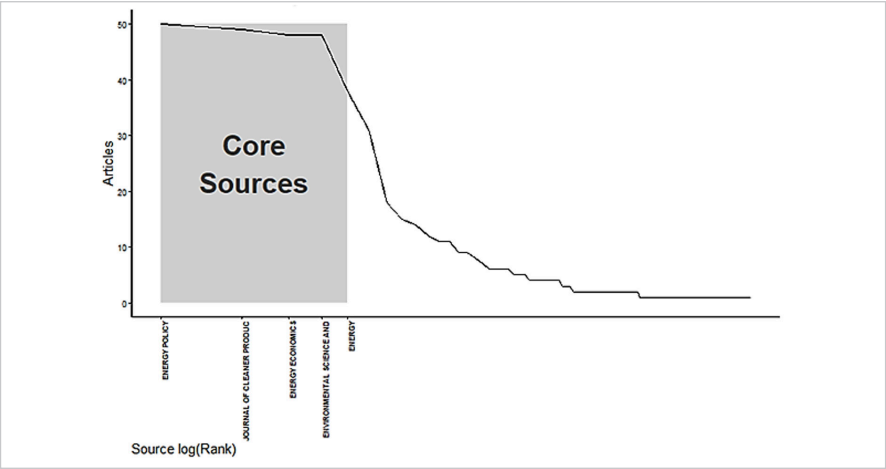


Source: Authors' work

3.3 Core Sources by Bradford's Law

Bradford's law illustrates that throughout the past three decades, there have been a small handful of exceptionally influential publications that have consistently published high-quality research. These publications probably hold a lot of weight and are cited regularly by experts in the subject. Journals and conferences can be seen scattered around the map, with their relative prominence and importance depicted by their location.

Figure 3. *Core Sources by Bradford's Law*



Source: Authors' work

According to the figures presented above, *Energy Policy* is now the most-cited journal, with 50 articles cited. This suggests that, out of the top 162 journals evaluated in the analysis, *Energy Policy* is the most productive on the topic of energy intensity and emerging economics.

3.4 Author Productivity through Lotka's law

It is consistent with Lotka's statement that most authors are not very productive and that just a few percent of authors publish an excessive number of publications.

According to Lotka's law, the productivity of authors has a power-law distribution. We can make the following inferences about the relationship between the presented table and Lotka's law: This trend is also shown in the table. Lotka's law predicts a high number of authors with low productivity, and the fact that the majority of authors have only produced a single paper is consistent with that prediction. There is a significant decrease in the proportion of authors who have written a certain number of articles as we move up the scale. For instance, the percentage of authors with more than one publication is lower than the percentage of authors with a single publication (about 11.71%). As the number of articles grows, this pattern persists. On the other hand, we

find that just a select few authors have produced a large number of publications. One author has written 22 articles, and just three others have written 10, 14, or 18 total. According to Lotka's law, these writers are in the minority but exceptionally productive.

Table 1. *Author Productivity through Lotka's law*

N. Articles	N. Authors	Freq
1	1050	0.79305136
2	155	0.11706949
3	49	0.03700906
4	29	0.02190332
5	11	0.00830816
6	9	0.00679758
7	3	0.00226586
8	5	0.00377644
9	5	0.00377644
10	1	0.00075529
11	4	0.00302115
14	1	0.00075529
18	1	0.00075529
22	1	0.00075529

3.5 Sources of Production over the Time Period

In general, publications on energy intensity and emerging economics can be found in the journals Energy Policy, Journal OF Cleaner Production, Energy Economics, Environmental Science AND Pollution Research, and Energy. While Energy Policy has maintained its preeminence, the Journal of Cleaner Production has made significant strides in recent years.

Table 2. *Sources of Production over the Time Period*

Year	Energy policy	Journal of cleaner production	Energy economics	Environmental science and pollution research	Energy
1993	1	0	0	0	0
1994	1	0	0	0	0
1995	1	0	0	0	0
1996	1	0	0	0	0
1997	1	0	0	0	0
1998	1	0	1	0	0
1999	1	0	1	0	0
2000	1	0	2	0	0
2001	1	0	2	0	0
2002	2	0	2	0	0
2003	2	0	2	0	0
2004	2	0	2	0	0
2005	2	0	3	0	0
2006	2	0	4	0	0
2007	3	0	4	0	0
2008	3	0	4	0	0
2009	7	0	4	0	0
2010	7	0	5	0	2
2011	12	0	5	0	2
2012	15	0	6	0	2
2013	18	0	7	0	2
2014	23	0	8	0	5
2015	29	0	10	1	9
2016	29	1	14	2	9
2017	31	5	20	2	9
2018	31	13	26	5	12
2019	36	27	30	11	17
2020	40	35	37	20	23
2021	43	45	43	33	30
2022	48	48	48	45	36
2023	50	49	48	48	38

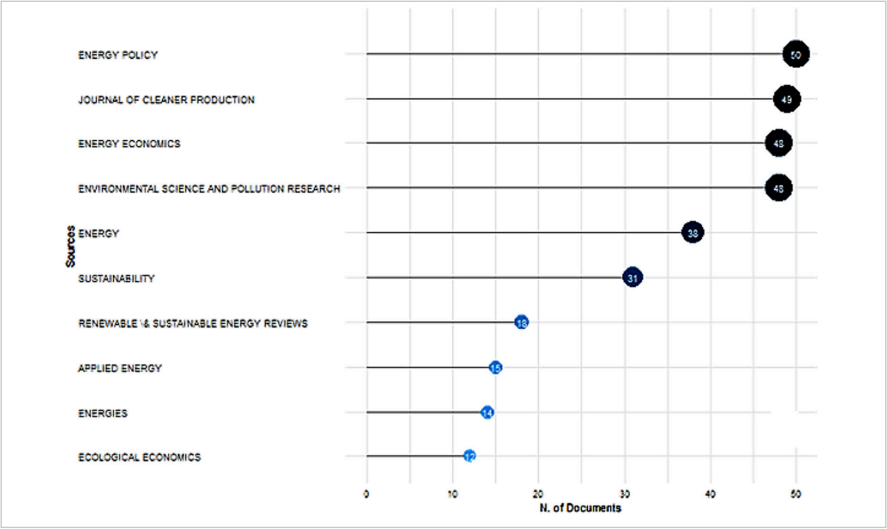
Articles on energy intensity and emerging economies have traditionally been most frequently published in these periodicals. It all began with a single article in 1993 and has since grown steadily. In 2023, when there were 50 publications published, interest in this area clearly peaked. There have been no new articles published in the Journal OF Cleaner Production since 2016. But it picked up steam after 2016 and, by 2023, had published 49 pieces, good enough for second place among recent sources. The number of papers published in the journal Energy Economics rose progressively, from zero in 1993 to a high of Between the years 2000 and 2010, it saw significant growth, and since then, its publishing rate has been pretty consistent. It was tied for third place in 2023 with 48 papers published. This journal has seen increased activity in recent years, particularly in the areas of environmental science and pollution research. There was a slow but steady increase in the number of publications, with a noticeable spike beginning in 2014. It was tied for third place in 2023 with Energy Economics for the number of papers it published: 48. Until 2010, no issues of the journal Energy were published. Although it did not begin publishing articles on energy intensity and emerging economies until 2010, it has now begun doing so. The number of articles published has been rising over time and will reach 38 by 2023.

3.6 Most Relevant Sources

The most relevant sources chart has made an important contribution to the literature on energy intensity and emerging economics by providing a visual depiction of the variable article counts across different sources, making comparisons between them much simpler.

The chart presents an illustration of the distribution of articles across various sources with regard to energy intensity in emerging economics. On the x-axis is the total number of articles, and on the y-axis is the total number of sources. The publication titled *Energy Policy* has been cited in the most articles, followed by the *Journal of Cleaner Production* and *Energy Economics.* While a few different sites offer a respectable number of articles, the majority of the others have a much lower total.

Figure 4. *Most Relevant Sources*



Source: Authors' work

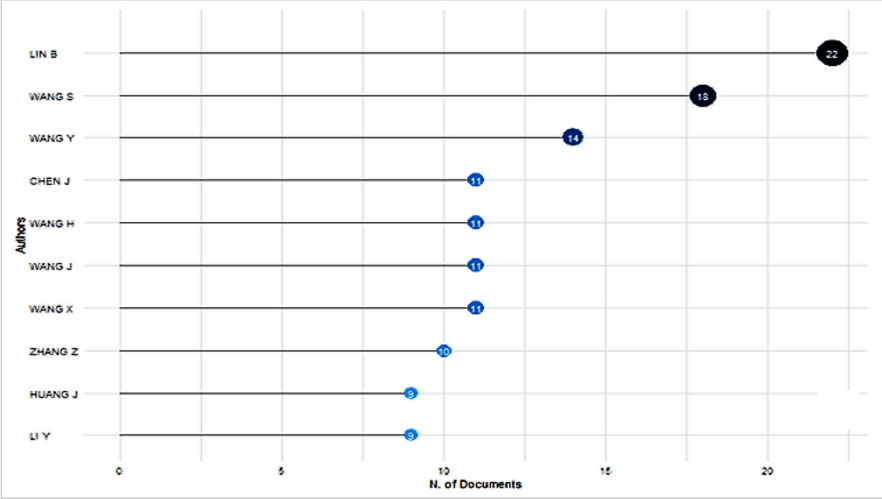
3.7 Most Relevant Authors

The field of energy intensity in emerging economies has greatly benefited from the work of these writers, both in terms of research and publications. Their combined efforts have increased our grasp of this key area, advancing the science and advancing sustainable energy practices in emerging economies.

The most influential researchers who have published articles on energy intensity in emerging economies over the past three decades are included in the figure. The authors are shown in descending order according to the total number of relevant articles they have written. Lin B: This writer has written the most published works (22). They have made a substantial contribution to the area by actively participating in research on energy intensity in emerging economies. Wang S. is the list's second-most prolific author, with 18 pieces to his name. Their research shows a deep interest in the subject and makes important strides toward clarifying the nature of energy intensity in emerging economies. WANG Y: This author has written 14 works on the topic, demonstrating a steady and substantial interest in studying energy intensity in emerging economies. Chen J., Wang H., Wang J., and Wang X.: These writers have

all written 11 publications apiece, indicating a similar level of commitment and interest in studying energy intensity in emerging economies. ZHANG Z: This author has put forth a lot of time and effort investigating energy intensity in emerging economies, as seen by the ten articles he has published on the topic. HUANG J. and LI Y.: These authors have published a combined total of nine publications, demonstrating significant participation in investigating and contributing to the understanding of energy intensity in emerging economies.

Figure 5. *Most Relevant Authors*



Source: Authors' work

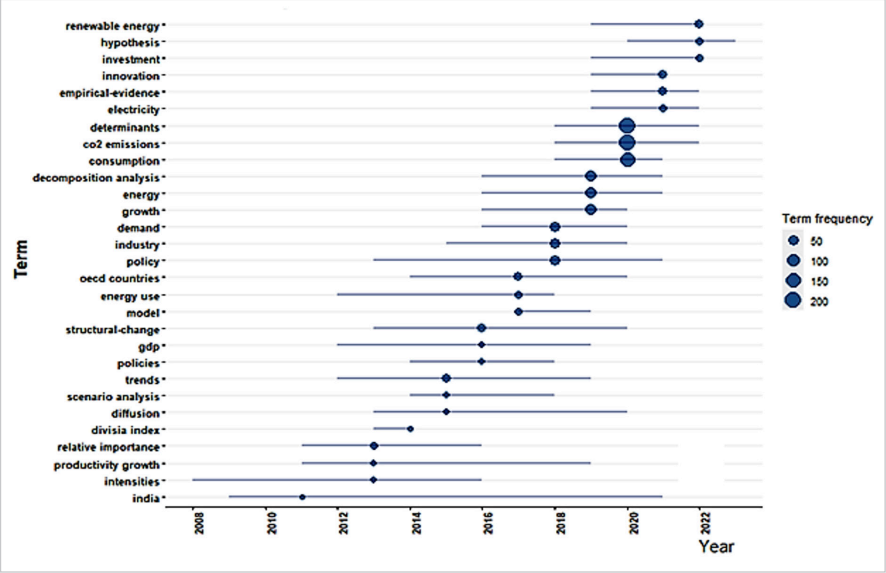
3.8 Trend Topics

The below chart summarizes a dataset by detailing the occurrences of each item and when they occurred. It draws attention to recurring themes and events by specifying the years in which they happened. Researchers and analysts can learn more about how the information has changed over time, and pinpoint popular topics and themes from different time periods.

Examples include a statement that India was mentioned in the graph (beginning in 2009 and ending in 2021). This suggests that India is a recurring theme or topic within the dataset. Likewise, the chart discusses other items such as relative importance, intensities, productivity growth, Divisia index,

trends, diffusion, structural change, GDP, policies, OECD countries, energy use, model, demand, industry, policy, decomposition analysis, energy, growth, determinants, CO2 emissions, consumption, innovation, empirical evidence, electricity, renewable energy, hypotheses, and investment.

Figure 6. *Trend Topics*



Source: Authors' work

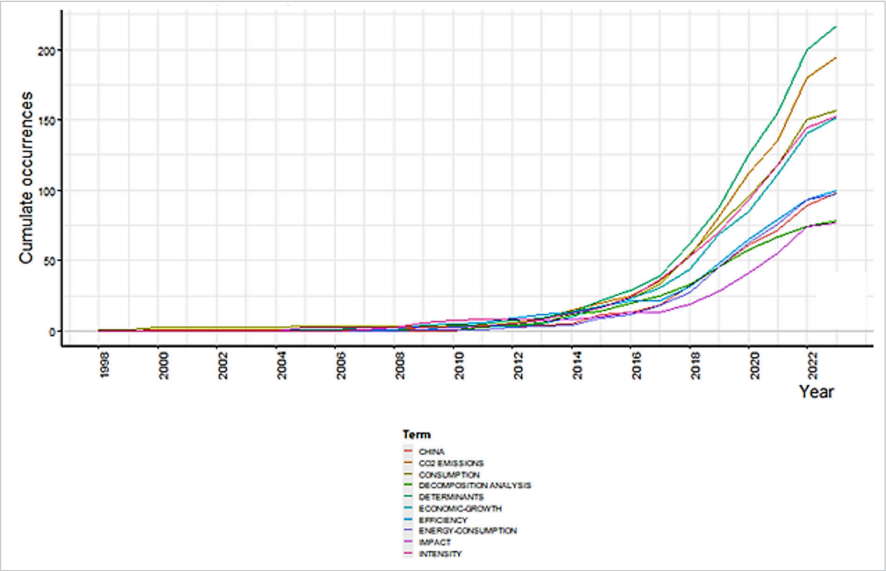
3.9 Words Frequency over Time

In general, the data points to an upward trend across the board for the majority of variables, revealing shifts and advances across a range of elements including drivers, CO2 emissions, consumption, and economic growth across the time period under consideration.

Several metrics from 1998–2023 are depicted here. In general, *Determinants, CO2 Emissions, Consumption,* and *Intensity* have been on the rise over time. In 2023, the greatest values for *Determinants* (217) and *CO2 Emissions* (195) can be found. The value of *Consumption* increases similarly, from 157 in 2022 to 217 in 2023. *Intensity* stays rather low across the years, reaching a maximum of 153 in 2023. *Economic Growth, Efficiency, China, Energy Consumption,*

Decomposition Analysis, and *Impact* all show general rises, while there is some variation between them.

Figure 7. *Words Frequency over Time*



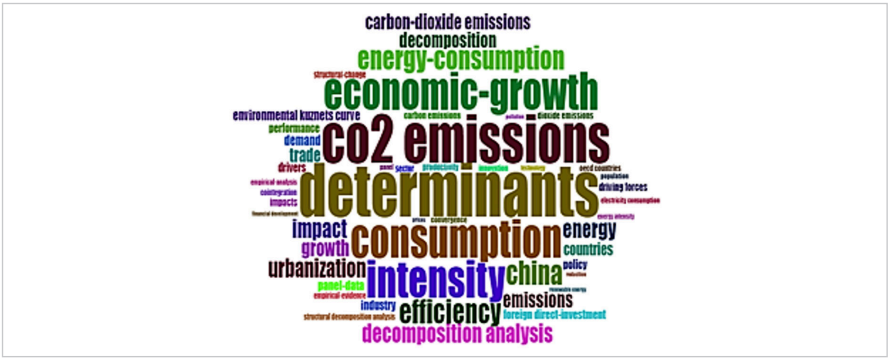
Source: Authors' work

3.10 Frequency count of term extracted

The most common ideas and topics in the data can be obtained from the frequency count of terms. This may help researchers and analysts determine which aspects of the dataset are most important.

In the above figure, extracted terms' frequency counts have been presented for convenience. It shows how frequently each term was used in the dataset, revealing the relative importance of various ideas. Words like *determinants* (217), *CO2 emissions* (195), *consumption* (157), *intensity* (153), and *economic growth* (152) stand out as having quite high frequency counts. Keywords that should not be overlooked include *efficiency, China,* and *energy consumption*. Researchers or analysts can better comprehend the content of the dataset by using the frequency count to discover the main subjects and areas of interest within the dataset.

Figure 8. *Frequency count of term extracted*



Source: Authors' work

3.11 Tree Map Chart

The tree map chart provides a visual overview of the frequency count of selected phrases within the dataset. A rectangular box for each term, with the size of the box related to the term's frequency. A tree map chart shows how often each term occurs in the data, making it easy to see with insight which terms are more frequently used than others.

Using the tree diagram as a basis: The largest rectangular box is a representation of the word *determinants,* which appears 217 times. The phrase *determinants* appears to be the most often used one in the data set. *CO2 emissions* (195), *consumption* (157), and *intensity* (153) are depicted in the following three largest rectangular rectangles: These words also have considerable weight in the data set. *economic growth* (152), *efficiency* (100), *china* (98), and *energy consumption* (97) are also noteworthy phrases with rather large rectangular boxes. The smaller squares stand for concepts like *decomposition analysis* (78), *impact* (77), *urbanization* (76), and *energy* (75). The terms *empirical analysis* (24), *electricity consumption* (24), and *panel* (23) are examples of low-frequency words, and their corresponding rectangular boxes are smaller.

Figure 9. *Tree Map Chart*

Source: Authors' work

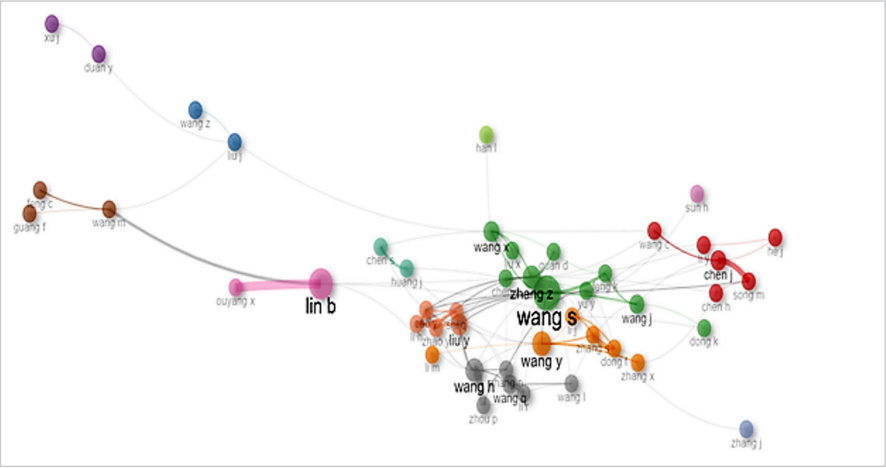
3.12 Author Collaboration Network Analysis

The figure depicts a network of author collaboration, with authors placed in distinct groups according to their tendencies to work together. Author roles and influence within the network are reflected by core measurements like Betweenness, Closeness, and page rank.

It looks like the authors' collaboration patterns have been analyzed in the provided table. Author information, including cluster membership and centrality measurements, is provided in the figure. The betweenness metric calculates how close an author is to all the other authors in the network of collaboration. This author's closeness to the other writers in the collaboration network is measured by the closeness metric. PageRank is a measure of an author's prominence or sway within a network of collaborators. Based on their tendencies to work together, authors are placed in one of several groups. Some inferences drawn from the data suggest that Cluster 1 authors *chen j, li y, song m, wang c,* and *chen h* have high values of Betweenness, suggesting that they are connected to many other authors in the network. Authors *wang z* and *liu*

j have the highest values of Betweenness, placing them at the center of their clusters' networks of interconnected authors. The authors *wang s, wang j, wang x,* and *zhang z* all have high PageRank values, placing them in a prominent position in the collaborative network; they are all members of Cluster 3. *Xu J* and *Duan Y* are authors who write in Clusters 4 and 5, respectively, and have low scores across all centrality measures, indicating that they are located on the periphery of their respective clusters. It's worth noting that the context and research subject at hand may affect how the analysis results are interpreted.

Figure 10. *Author Collaboration Network Analysis*



Source: Authors' work

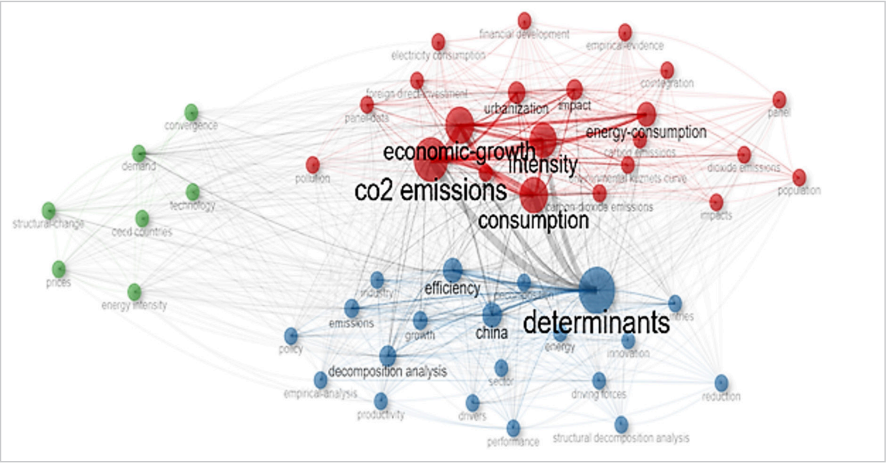
3.13 Cooperation Word Network Analysis

This group covers a wide range of topics, including demand, structural change, convergence, OECD countries, energy intensity, technology, and prices. Centrality measurements, which reveal the most significant nodes and the roles they play, aid in understanding the structure and dynamics of a cooperation network.

The figure shows the clustering, Betweenness centrality, Closeness centrality, and PageRank scores of the nodes in the author collaboration network. Cluster 1 nodes cover a wide range of ground, including but not limited to carbon

dioxide (CO2) emissions, consumption, intensity, economic growth, energy consumption, effect, urbanization, carbon dioxide emissions, and trade. These nodes have a high Betweenness centrality, suggesting they play an important role in linking together various subsets of the network. Cluster 2 nodes cover ground including drivers, effectiveness, China, breakdown analysis, power, expansion, pollution, and manufacturing. They also have high levels of Betweenness centrality, which indicates they play a crucial role in promoting interaction amongst members of the same cluster. Finally, nodes with intermediate Betweenness centrality values may be found in Cluster 3.

Figure 11. *Cooperation Word Network Analysis*



Source: Authors' work

4. Conclusion

In conclusion, emerging economies' energy intensity levels are shaped by a complex interplay of determinants that were highlighted by the analysis of factors influencing energy intensity on economic growth. In order to achieve a more sustainable and resilient energy future, emerging economies must first address these determinants through research, collaboration, and policy actions. The *Annual Scientific Production* figure's findings illustrate the growing body of knowledge and the persevering attempts to tackle energy efficiency difficulties, highlighting the significance of ongoing research and collaborative efforts in driving progress. The increasing recognition and impact of research on the topic is seen in the *Average Citations per Year* figure, demonstrating substantial contributions to the research area. The importance of determining and employing core sources to gain access to significant material and maintain awareness of recent advances is highlighted by the *Core Sources by Bradford's Law* figure. The *Author Productivity through Lotka's Law* table emphasizes how important it is to identify highly productive authors and examine author productivity patterns for assessing research trends and contributors in the field of energy intensity towards emerging economies. The analysis sources of Production over the time period, most relevant sources and most relevant authors connected to energy intensity in developing economies shows the dominance of particular sources, the importance of key sources and authors, and the ongoing nature of trend issues in this field.

To get insight into the research landscape and to improve information sharing and collaboration, it is helpful to understand the distribution of sources and to identify relevant authors. The trend topics figure shows the frequency and distribution of subjects, reflecting shifts in research focus and policy significance. These findings help academics, policymakers, and stakeholders understand the shifting research environment and suggest crucial areas for energy intensity study and action in emerging economies. The words frequency, frequency count of term extracted, and tree map analysis help track changes, comprehend key concepts, and understand the relative relevance and prevalence of terms in the examined content. Author collaboration network study shows authors' important contributions to energy

intensity in emerging economies, improving knowledge and sustainable energy practices. Cooperation word network analysis gives a glimpse into the collaboration network structure, but further study is needed to understand collaboration patterns and dynamics. It is possible to attain a more sustainable and adaptive energy future, as well as economic growth and development, by making it a priority in emerging economies to focus on reducing energy intensity and increasing sustainability.

This research on the determinants of energy intensity in the emerging economies has enriched the findings of the literate on the burning issue. The analysis of research trends, geographic concentration, important authors and publications, interdisciplinary research, and research gaps has resulted in the following main findings. The research has elaborated on the major topics and the changing trends, pointing to areas with substantial scholarly content and shifts in geographical focus. The impact assessment has also highlighted key authors and publications, which reflect the different strategies for investigating energy intensity determinants and calls for interdisciplinary knowledge. On the other hand, the study has certain shortcomings, for example, biased selection of databases and search terms influencing the scope of the literature review. Furthermore, the research method of the study might have left unexplored the qualitative details and context-specific matters of individual papers. Although these limitations exist, this study contributes important knowledge that underlines the need for continued academic research and evidence-based policy. Policies, therefore, would be crafted in a manner that promotes transition towards sustainable development.

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