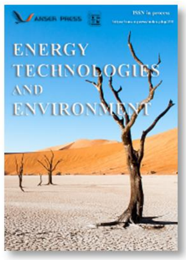
ANSER PRESS

Energy Technologies and Environment

Homepage: https://www.anserpress.org/journal/ete



The Role of Oscillations in Macroeconomic and Financial Factors in the Production of Renewable Energy: A Case Study of Selected South Asian Economies

Shahid Ali [a, *]

[a] *North China Electric Power University, Beijing, China*

ABSTRACT

The objective of this study is to explore the link between the financial sector, macroeconomic fluctuations, and sustainable energy production in South Asia. It evaluates existing research, identifies gaps, and suggests future directions. The study emphasizes the need to understand how economic activities influence the environment and how environmental factors impact economic and financial outcomes. It also examines financial market responses to understand the manifestation of economic and environmental factors, using data from Bangladesh, India, Pakistan, and Sri Lanka spanning 1987 to 2022. The results show that investment in green energy is essential for developing countries. The study suggests that the relationship between the region's stock market, GDP, carbon emissions, and green energy is complex, with a negative response to domestic credit indicating potential obstacles to investment, such as policy barriers or insufficient incentives. Mixed responses highlight the need for credit directed towards sustainable projects. Variations in responses across economic indicators may indicate policy challenges or structural issues, necessitating a reassessment of government policies to incentivize sustainable investments and promote green technology adoption. These results imply that policymakers should precisely assess the environmental ramifications of economic growth and stock market activities. This presents an opportunity to craft policies that guide investments toward cleaner technologies and industries, aligning economic growth with sustainable practices. Policymakers and financial institutions should explore ways to incentivize green energy investments and promote sustainable economic growth.

KEYWORDS

Green energy investment; Carbon emissions; Financial sector; Macroeconomic fluctuations; South Asia

---

* Corresponding author: Shahid Ali
E-mail address: 120194300011@ncepu.edu.cn

ISSN 2972-4899
doi: 10.58567/ete02030001

Received 31 December 2023; Accepted 18 April 2024; Available online 4 July 2024.

1. Introduction

The relationship between economic development, environmental sustainability, and financial dynamics has become a focal point of research in recent years (see, for example, Sethi et al., 2020; Khan et al., 2022). Fossil fuel, a key source of basic energy, considerably influences economic growth and macroeconomic indicators. Oil price shocks of the 1970s were characterized by high unemployment, inflation, and sluggish growth. However, since the mid-1980s, the relationship between oil prices and macroeconomics has eroded. Increases in oil prices can cause inflation and slow economic development and employment. Elevated oil prices increase manufacturing and transportation expenses, leading to higher costs for goods and services. The surge in oil prices has constrained the production of goods and services, exacerbating unemployment rates. This has implications for inflation, corporate profitability, investment dynamics, and productivity. It also diminishes overall wealth and raises concerns about future economic conditions, affecting demand dynamics and overall wealth.

The existing literature extensively employs aggregate stock market indices to illustrate the adverse correlation between rising fossil fuel use and negative stock market returns. In contrast, a prevailing trend in research indicates that as the use of non-renewable fuel reduces, alternative energy stock prices tend to experience favorable returns (e.g., Sardorsky, 2008; Kumar et al., 2012; Managi and Okimoto, 2013). Nevertheless, the effects of both positive and negative fluctuations in the stock prices of clean energy companies exhibit considerable variation over short and long time frames (Kocaarslan and Soytas, 2019). Consequently, the current state of research on the interaction among green energy sources, stock market volume, and other macroeconomic factors become pivotal. Other asset groups, such as technology and investment, are also important. Various scholars underscore the importance of considering stock markets when valuing renewable energy sources (Zhang et al., 2018). Additionally, some researchers delve into the role of commodities, such as gold and silver, as potential mitigators of risks associated with the fluctuations in clean energy stocks (Kilian, 2008). Another strand of research explores the relationship between green bonds and the dynamics of the clean energy market (Allegret et al., 2015). Gaining insights into the mechanisms governing the variability in alternative energy prices is crucial for market participants, especially environmentally conscious investors, to comprehend their exposure to price volatility and the underlying forces at play (Broadstock and Filis, 2014). Policymakers are urged to formulate regulations that address the risk of contagion stemming from the volatility of these asset types (Creti et al., 2014). This multifaceted approach aims to enhance comprehension and risk management within the evolving landscape of clean energy investments.

The dynamic relationship between macroeconomic fluctuations and environmental sustainability, particularly their impact on energy production, is multifaceted. It involves various economic, social, and environmental factors that interact and influence each other. Environmental conditions can influence macroeconomic trends, further complicating the relationship. This idea posits two fundamental queries discussed below, which pave the direction objectives this research addresses.

Corollary I: How Macroeconomic Fluctuations Affect Environment and Energy Production:

- Investment and Innovation: Economic expansions often lead to increased investment in research and development, promoting cleaner and sustainable energy technologies, while contractions may result in reduced funding, stifling the progress of environmentally friendly technologies during periods of economic stability.
- Consumption Patterns: Economic booms can increase energy consumption due to increased industrial production and consumer demand, potentially utilizing conventional, less sustainable energy sources. Conversely, economic downturns can lead to decreased energy consumption due to reduced industrial activities, potentially promoting cleaner energy sources.

- Policy and Regulation: Macroeconomic conditions significantly impact government policies and regulations, with periods of economic growth promoting environmental regulations. In contrast, economic downturns may result in regulatory rollbacks due to short-term economic recovery.
- Renewable Energy Investment: Economic stability boosts renewable energy investment, with growth periods offering more robust financing. However, economic downturns can create financial constraints, potentially slowing down investments in renewable energy infrastructure.

Corollary II: How Environment and Energy Production Affect Macroeconomic Fluctuations:

- Resource Scarcity and Price Volatility: Environmental degradation and resource scarcity can lead to energy market price volatility, with sudden disruptions affecting macroeconomic stability, inflation, and economic uncertainties, potentially causing geopolitical tensions.
- Transition to Clean Energy: Transitioning to cleaner energy sources can boost economic activity by creating jobs and contributing to growth while also enhancing energy security and reducing vulnerability due to dependence on exhaustible resources.
- Climate Change Impacts: Extreme weather events, sea-level rise, and natural disasters can significantly impact economic productivity, disrupt supply chains, damage infrastructure, and cause substantial economic losses, affecting macroeconomic stability.
- Policy and Regulatory Effects: Environmental policies reducing carbon emissions can impact industries and markets, impacting economic performance. Sustainable practices can stimulate innovation and create new opportunities in the renewable energy sector.

This study examines the relationship between financial advancement, macroeconomic fluctuations, and sustainable energy production in South Asia. It aims to evaluate existing research, identify gaps in understanding, and suggest future research directions. The study focuses on the impact of economic growth on key indicators like per capita GDP, CO2 emissions, electricity generation, stock market prices, gross fixed capital formation (GFCF), and credit. Integrating environmental factors with economic and financial indicators underscores the need to understand how economic activities influence the environment and how environmental factors impact economic and financial outcomes. The study also explores financial market responses, such as stock market prices and credit dynamics, to understand how economic and environmental factors manifest in the financial domain. The concept of Gross Fixed Capital Formation (GFCF) further explains the role of investment in driving economic growth and shaping environmental and financial outcomes. This comprehensive analysis is crucial for policymakers, economists, and environmentalists seeking sustainable economic development.

Against this backdrop, this study endeavors to contribute to the existing literature by employing a Structural Vector Autoregressive (SVAR) model to unravel the dynamic relationships among GDP per capita, CO2 emissions, electricity production, stock exchange prices, investment (GFCF), and credit to the private sector. By employing an empirical approach, this research aims to discern the nuanced interactions between these variables, providing a basis for informed decision-making and policy recommendations in the pursuit of a harmonious balance between economic growth, environmental sustainability, and financial stability.

After this introduction, section 2 reviews the existing literature, section 3 presents the empirical model and methodology, section 4 discusses the results and findings, and section 5 concludes.

2. Literature Review

2.1. Macroeconomic Fluctuations and Environmental Impact

The investigation into the relation between fluctuations in macroeconomic conditions, such as changes in GDP growth rates, inflation levels, and unemployment rates, and environmental factors, including climate change, pollution levels, and resource depletion, as well as energy production, has emerged as a central area of interest within the realm of academic research. This critical literature review examines key research findings, methodologies, and gaps in understanding this multifaceted interaction. The existing body of research has explored the general correlation between oil prices and stock market activity. Many studies have utilized overall stock market indices to demonstrate that an upswing in oil prices correlates with a downturn in stock market returns (e.g., Creti et al., 2014; Broadstock and Filis, 2014; Ghosh and Kanjilal, 2016; Degiannakis et al., 2014). While there seem to be varied responses to changes in oil prices depending on the sector (Broadstock and Filis, 2014), most of the literature indicates that escalating oil prices yield positive returns on stocks within the alternative energy sector (Sardorsky, 2008; Kumar et al., 2012; Managi and Okimoto, 2013, among others). This critical literature review synthesizes key insights from seminal works, methodological approaches, and integrated studies to unravel the complexities of this multifaceted relationship.

Acemoglu et al.'s (2012) exploration of directed technical change delves into how environmental concerns influence the trajectory of technological progress. Dell et al. (2012) contribute by examining the historical interplay between climate change and economic growth. Shifting the focus to energy production within the framework of macroeconomic dynamics, Apergis and Payne's (2010) study investigates the relationship between renewable energy consumption and economic growth. Brunnermeier & Landau (2022) delve into the intricacies of aligning financial systems with climate goals. Cherp and Jewell (2014) explore the concept of energy security, emphasizing its evolution amidst changing macroeconomic conditions.

However, Kocaarslan and Soytas (2019) have demonstrated that the positive and negative shifts in oil prices on the stock prices of clean energy companies significantly differ in both short- and long-term perspectives. Consequently, the state of research on the impact of oil prices on the stock prices of clean energy firms remains inconclusive. Stern's (2007) influential Economics of Climate Change underscores the urgency of addressing climate-related challenges and highlights the economic implications of environmental shifts. Some studies, such as Doda et al.'s (2015) analysis of industrial action on energy policy outcomes and Müller and Schmidt's (2020) examination of the political economy of renewable energy production in Germany, provide nuanced perspectives. Financial development plays a crucial role in facilitating the growth of renewable energy projects. Researchers such as Ang (2019) argue that well-developed financial markets are essential for attracting investment in renewable energy initiatives. Countries with robust financial sectors like Japan and South Korea have witnessed significant advancements in renewable energy production in Asia. However, the relationship is complex, as highlighted by Du, Wei, and Wei (2020), who found that the impact of financial development on renewable energy varies across different Asian economies.

One key aspect is the role of banking institutions in financing renewable energy projects. Studies by Zhang et al. (2018) reveal that countries with a proactive banking sector are more likely to channel funds into renewable energy ventures. Conversely, nations with underdeveloped financial markets may struggle to attract sufficient investment, hindering the expansion of their renewable energy capacities. It is imperative to recognize these nuances when evaluating the relationship between financial development and renewable energy production in Asia.

Methodological considerations are addressed through Ang's (2004) discussion on decomposition analysis and Lütkepohl's (2006) insights into structural vector autoregressive models. Yet, Bassi and Van Sinderen's (2007) work on climate policy and renewable energy in Brazil and Miketa and Schrattenholzer's (2004) experiences with long-term energy scenarios reveal gaps and challenges in financial mechanisms and scenario development. As the literature underscores progress, it simultaneously emphasizes the need for future research to fill gaps, employ robust methodologies, and inform policy in a rapidly evolving global context.

2.2. Macroeconomic Oscillations and Renewable Energy

Macroeconomic oscillations, characterized by economic boom and bust cycles, introduce a layer of complexity to the renewable energy landscape. During economic downturns, governments may prioritize short-term economic stability over long-term investments in renewable energy. This is evident in studies by Liu and Zhang (2017), who observed a slowdown in renewable energy projects during periods of economic recession in certain Asian countries. Conversely, some scholars argue that economic downturns can stimulate interest in renewable energy as governments seek alternative sources of economic growth (Tang, 2018). The relationship between macroeconomic oscillations and renewable energy production in Asia is multifaceted, requiring a nuanced understanding of each country's specific economic, political, and social contexts.

2.3. Interactive Dynamics

Financial institutions may become risk-averse in times of economic uncertainty, leading to reduced funding for renewable energy projects. Conversely, well-established financial markets can stabilize during economic downturns, providing a buffer for the renewable energy sector (Huang et al., 2019). Moreover, government policies are pivotal in shaping the interaction between financial development, macroeconomic oscillations, and renewable energy production. For instance, countries with supportive policy frameworks and incentives are more likely to weather economic uncertainties and attract sustained investment in renewable energy (Wang et al., 2021). Understanding the dynamic relationships between these factors is crucial for devising effective strategies to promote renewable energy in the diverse Asian economic landscape.

Studies have shown that financial development, particularly the development of financial institutions such as banks, positively impacts renewable energy consumption from a macro perspective (Sun et al., 2023). Additionally, the depth, access, and efficiency of financial institutions and the development of financial markets also contribute to the promotion of renewable energy consumption (Obobisa, 2022). However, the impact of financial development on $CO2$ emissions varies across regions. While financial development increases $CO2$ emissions in Africa, Asia-Pacific, and globally, it decreases $CO2$ emissions in America and Europe (Kim & Park, 2016). Furthermore, the growth of the renewable energy sector is facilitated by well-developed financial markets, which provide easier access to external financing (Amuakwa-Mensah & Násström, 2022). Overall, a well-functioning banking sector is crucial for ensuring the necessary investments in renewable energy and achieving the goal of reducing $CO2$ emissions.

The literature review highlights the interconnected factors influencing Asia's renewable energy production, emphasizing the need for comprehensive, regionally focused, and longitudinal research to bridge existing knowledge gaps. Research often overlooks technological innovation's impact on financial viability and macroeconomic susceptibility on renewable energy projects. Future studies should explore the intricate relationship between technology, financial development, and macroeconomic fluctuations to understand the factors shaping Asia's renewable energy landscape. Understanding the intricate relationships between finance, macroeconomics, and renewable energy production is crucial for promoting sustainable and resilient renewable energy development in Asia, contributing to academic discourse, and assisting policymakers, investors, and industry stakeholders.

3. Model and Methodology

To address the questions discussed in section 1, we now define a proper model to determine the relationships between macroeconomic factors and the energy and environment. The choice of the variables used with the underlined methodology is a novel feature of this study.

To comply with the cyclical innovations, let's modify the structural VAR model to include a log of GDP per capita (LY), log of total CO2 emissions (LCO), non-fossil Energy production (E), Stock exchange value (LS), Gross Fixed Capital Formation (LCF), and Domestic credit to the private sector (DC):

$$\begin{bmatrix} LY_t \\ LCO_t \\ E_t \\ LCF_t \\ LS_t \\ DC_t \end{bmatrix} = \begin{bmatrix} b_{01} \\ b_{02} \\ b_{03} \\ b_{04} \\ b_{05} \\ b_{06} \end{bmatrix} + \begin{bmatrix} a_{11}a_{12}a_{13}a_{14}a_{15}a_{16} \\ a_{21}a_{22}a_{23}a_{24}a_{25}a_{26} \\ a_{31}a_{32}a_{33}a_{34}a_{35}a_{36} \\ a_{41}a_{42}a_{43}a_{44}a_{45}a_{46} \\ a_{51}a_{52}a_{53}a_{54}a_{55}a_{56} \\ a_{61}a_{62}a_{63}a_{65}a_{65}a_{66} \end{bmatrix} \begin{bmatrix} LY_{t-1} \\ LCO_{t-1} \\ E_{t-1} \\ LCF_{t-1} \\ LS_{t-1} \\ DC_{t-1} \end{bmatrix} + \begin{bmatrix} \epsilon_{y,t} \\ \epsilon_{co,t} \\ \epsilon_{E,t} \\ \epsilon_{LCF,t} \\ \epsilon_{s,t} \\ \epsilon_{DC,t} \end{bmatrix} \quad (1)$$

Equation (1) has a unique feature: we define the variables of interest in the top three rows. In contrast, the given macroeconomic variables include investment, stock exchange volumes, and the domestic credit to the private sector. We assume the credit variable represents the policy variables, plus financial innovations, while the stock exchange variable represents financial oscillations. In this model, aij are the coefficients in matrix A, capturing the contemporary impact of the variables on each other. **ϵ**i,t are the structural shocks or innovation.

We summarize Equation 1 as follows:

$$X_t = \beta_0 + A1X_{t-1} + e_t \quad (2)$$

Xt represents contemporaneous while Xt-1 shows the instantaneous behavior of each variable in this model specification. The detailed derivations of such models can be found in VAR literature (such as Bernanke & Mihov, 1998; Shahab & Mahmood, 2012; Ma et al., 2022).

To empirically test the model, we first applied the unit root test and then used the SVAR approach to find the impulse responses of each variable. The estimated VAR residuals show a high level of volatility in some cases. The annual data of 36 years spanning 1987-2022, is used to analyze four south Asian economies, including Bangladesh, India, Pakistan, and Sri Lanka.

4. Empirical Findings: Test of SVAR Approach

4.1. Descriptive Analysis

To be in line with the objectives of this study, the data are first analyzed for descriptive purposes. Table 1 shows the basic statistics about the variables of the model. The highest variation is observed in green energy production, followed by domestic credit to the private sector. The GDP per capita of these countries has shown the lowest variation because these countries belong to almost the same income group and have very close socio-cultural structures. Due to geographic connectedness, the CO2 emissions also show very small standard deviations. The data, in a nutshell does not exhibit normality property, as the value of the Jarque-Bera test indicates.

Table 1. Descriptive Stats.

Indicators	LY	LCO	ELEC	DCPS	LCF	LSTK
Mean	7.08	11.31	33.13	29.74	24.10	22.61
Median	7.05	11.23	30.02	26.72	24.03	21.59
Maximum	8.41	14.71	99.84	54.57	27.68	28.54
Minimum	6.14	7.90	1.12	8.82	21.14	17.89
Std. Dev.	0.57	1.85	25.20	11.54	1.64	2.94
Skewness	0.50	0.31	0.98	0.44	0.45	0.42
Kurtosis	2.77	2.05	3.49	2.24	2.51	1.91

Jarque-Bera	6.24	7.82	24.61	8.23	6.42	11.38
Probability	0.04	0.02	0.00	0.02	0.04	0.00
Sum	1019.90	1628.78	4771.05	4282.72	3471.12	3255.51
Sum Sq. Dev.	46.55	490.57	90793.32	19032.93	386.37	1235.24
Observations	144	144	144	144	144	144

Then, we estimated the confidence ellipse between domestic credit to the private sector and renewable energy production, among renewable energy and environment, investment and environment, and stock market value and environment. Figures 1-4 show the direction of the relationship. The confidence Ellipse between Credit and Energy shows a negative correlation (but large) between both in Bangladesh, India, and Sri Lanka, whereas, a very small but positive relationship in Pakistan. The confidence ellipse between renewable energy and pollution is high and negative in all four economies. As indicated by Figure 3, the confidence ellipse between Investment and Environment is very granular, showing a high but positive correlation between both, i.e., investment activities generate pollution. Investment in the stock market and renewable energy production have a low correlation in case of Pakistan, whereas negative and medium in all other cases.

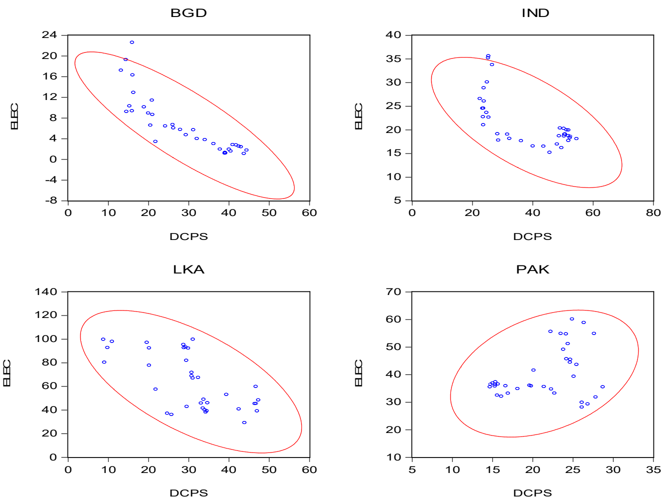


Figure 1. Confidence Ellipse between Credit and Energy.

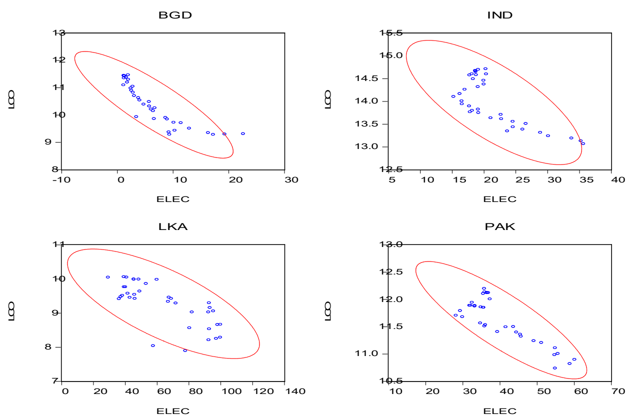


Figure 2. Confidence Ellipse between renewable Energy and the environment.

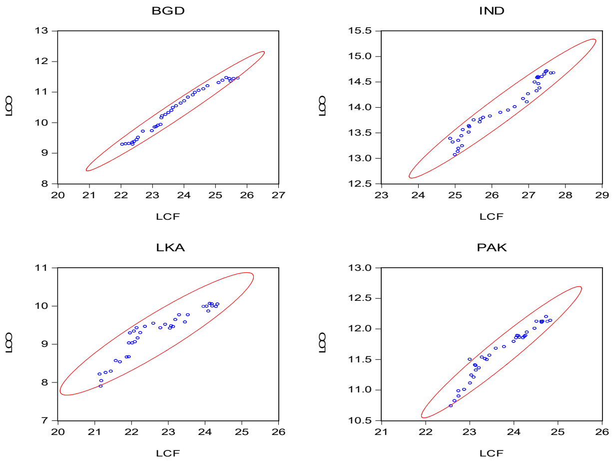


Figure 3. Confidence Ellipse between Investment and Environment.

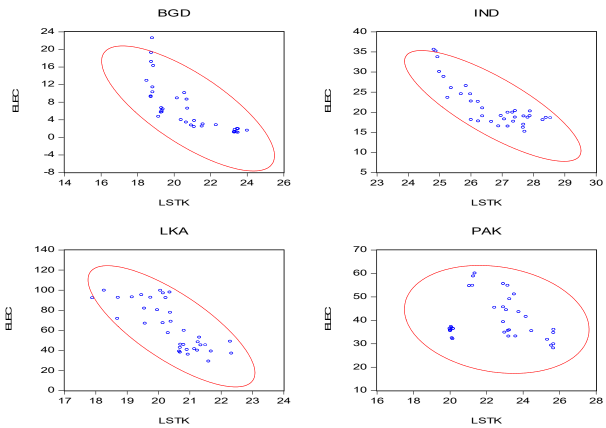


Figure 4. Confidence Ellipse between Stock market and renewable Energy.

4.2. SVAR Approach

After applying the unit-root test for panel data, the mixed order of integration among the variables is assumed (to converse space, we have not shown its results here). However, the Structural VAR methodology is preferred over ARDL because VAR model does not require the specific order of integration of certain dependent variables. Moreover, it can further take us to estimate the impulse responses, variance decomposition, and long run and short-run stable coefficients. It also shows the fluctuations we are looking for among the variables of interest. We discuss these factors turn by turn.

4.3. Impulse Responses:

Figure 5 shows that due to a positive shock in per capita GDP, the carbon emission in South Asian economies respond positively. This response is stable over the long run. The initial response of renewable energy is approximately zero. Still, sooner it becomes negative, indicating that over the long run, high growth trajectory reduces the chances of investing in green energy until a certain point of economic development is achieved. In these middle-income south Asian economies, this point has not yet been achieved. Credit to the private sector and investment respond positively, but the stock market over the periods shows negative response to shock in the economy.

The response of GDP per capita, investment, green energy stock market, and domestic credit to the private sector following a shock in carbon emissions is shown in Figure 6. A negative response in GDP per capita indicates that an increase in carbon emissions leads to a decrease in GDP per capita. This could be because certain industries, potentially carbon-intensive ones, hamper output. A positive response of investment to a shock in carbon emissions suggests that there is an economic incentive to invest in industries related to carbon emissions or in technologies aimed at mitigating the impact of emissions. Green Energy Stock Market Response An initially negative response to the green energy indicates investors' delayed response to green energy production due to pollution. A delayed stock market response indicates that investors view an increase in carbon emissions as an opportunity for growth in the stock market for renewable energy assets. An increase in domestic credit to the private sector following a shock in carbon emissions may suggest that financial institutions perceive business opportunities or increased demand in sectors affected by the carbon shock.

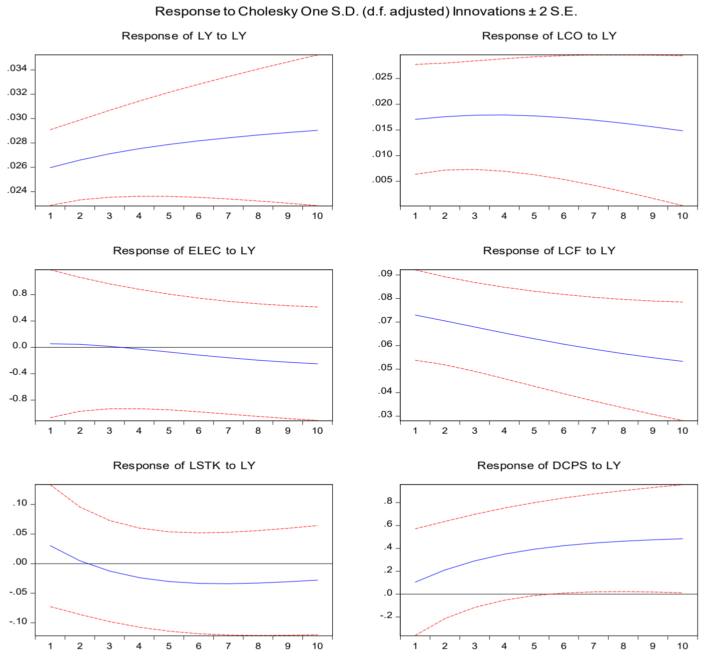


Figure 5. Response of All variables to a shock in LY.

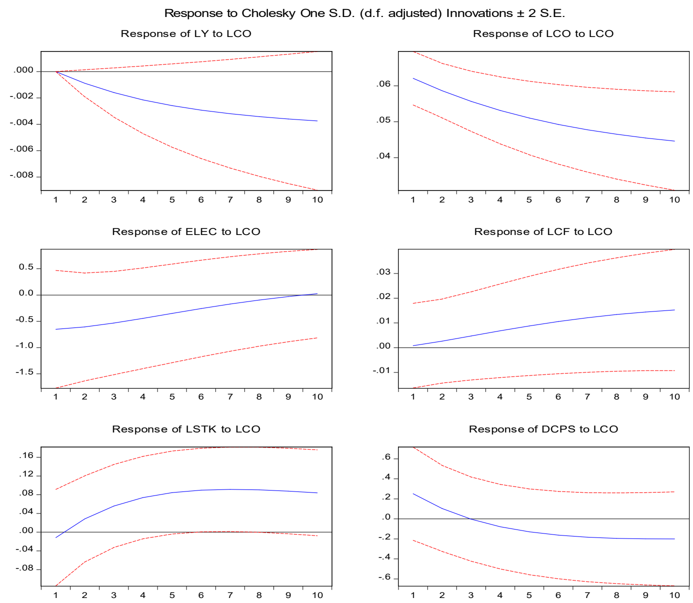


Figure 6. Response of All variables to a Shock in Emissions.

Figure 7 analyzes the impulse response of GDP per capita to a shock in green energy and involves understanding how an exogenous change or shock in green energy affects the trajectory of GDP per capita over time. A negative impulse response implies that a shock in green energy is associated with a decline in GDP per capita. This negative response might occur if the costs of transitioning to green energy sources outweigh the benefits in the short term, leading to economic disruptions. It could also occur if the economy heavily relies on traditional, carbon-intensive industries that experience negative shocks due to the transition to green energy. A delay in the response could suggest that the full economic effects of the shock take time to materialize. On the other hand, a positive impulse response in carbon emissions implies it is associated with an increase in carbon emissions. This unexpected response would raise concerns as it contradicts the expected environmental benefits of transitioning to green energy. Possible explanations for a positive response might include inefficiencies in adopting green technologies or unintended consequences that lead to increased emissions. A delayed and negative impulse response would imply that the shock in green energy is associated with a decrease in investment. This is also an unexpected response, suggesting that the transition to green energy may face challenges or that investors perceive uncertainties and risks associated with green technologies in developing economies of South Asia.

Figure 8 shows that in the context of South Asian economies, a positive response of GDP and carbon emissions to investment and a negative response of green energy to investment may be interpreted in several ways. A positive response of GDP to investment suggests that increased investment contributes to economic growth in South Asian economies. Various factors, such as infrastructure development, increased production capacity, and job creation could drive this. The positive response of carbon emissions to investment may indicate that the investments made in South Asian economies are associated with activities that contribute to higher carbon emissions. This might be due to a reliance on carbon-intensive industries, such as manufacturing and energy production, which are common in developing economies. The negative response of green energy to investment implies that, despite overall investment, the growth or adoption of green energy practices is not keeping pace. This could be due to a lack of sufficient investment in renewable energy projects, inadequate policy support, or challenges in transitioning to a more sustainable energy sector.

It's crucial to conduct a detailed empirical analysis to validate these interpretations and understand the specific factors influencing the relationships between investment, GDP, carbon emissions, and green energy in the context of South Asian economies. Additionally, considering the diverse nature of countries within the region, variations in policy frameworks and economic structures should be considered for a more nuanced interpretation.

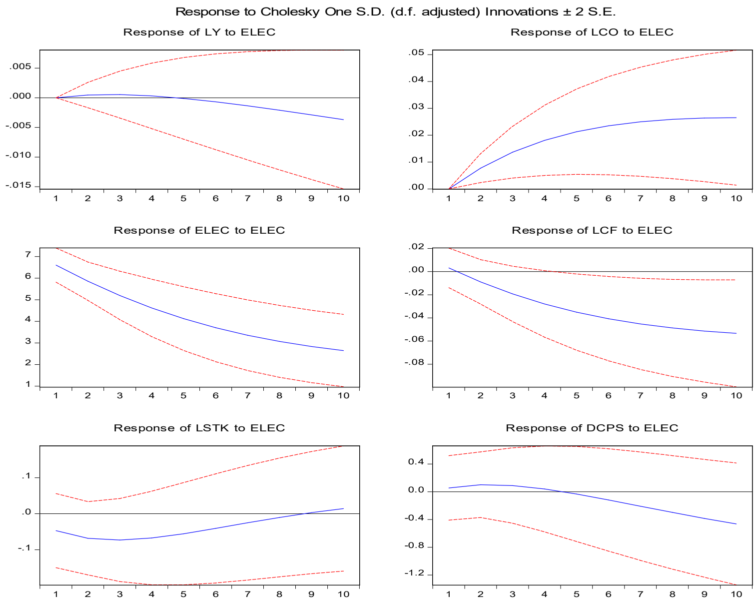


Figure 7. Response to Green Energy Shock.

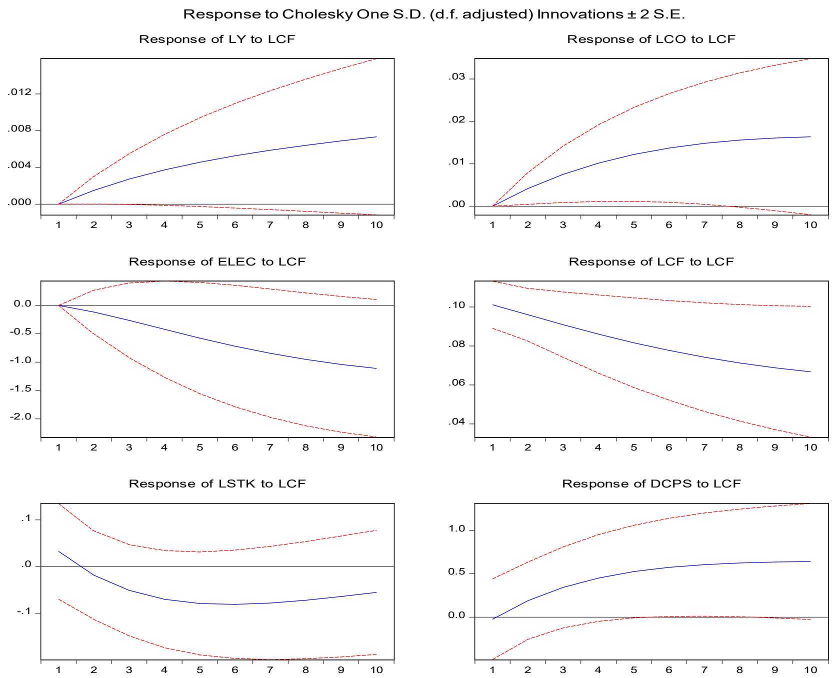


Figure 8. Response to Investment Shock.

Figure 9 presents a positive response of GDP, carbon emissions, and green energy to the stock market in the context of South Asian economies. A positive response of GDP to the stock market implies that a robust and growing stock market contributes to overall economic growth. This may be due to increased investor confidence, improved corporate performance, and an influx of capital into the economy. However, caution is needed to ensure that stock market gains reflect genuine economic productivity and not speculative bubbles. Similarly, the positive response of carbon emissions to the stock market suggests that economic activities linked to stock market growth may be associated with industries that contribute to higher carbon emissions. Industries such as manufacturing, construction, and energy production often play a significant role in emerging economies and may contribute to increased emissions. The positive but delayed response of green energy to the stock market indicates that the stock market's growth is associated with increased investment and support for the green energy sector. This could reflect a positive trend in investor interest and confidence in environmentally sustainable practices. The simultaneous positive responses of GDP, carbon emissions, and green energy to the stock market could suggest that economic growth in South Asian economies is tied to industries with positive and negative environmental implications. This scenario emphasizes balancing economic development with sustainable and environmentally friendly practices.

In Figure 10, a delayed positive response of GDP to domestic credit to the private sector suggests that increased access to credit stimulates economic activity over time. Businesses may take time to utilize the additional credit effectively, invest in projects, and contribute to overall economic growth. Moreover, the delayed positive response of CO2 emissions to domestic credit suggests that the increased economic activity fueled by credit is associated with a subsequent rise in carbon emissions. This delay could result from the time it takes for industries to scale up production, leading to an eventual increase in energy consumption and emissions. On the other hand, the negative response of green energy to domestic credit indicates that despite increased credit availability, investments in the green energy sector may not be growing proportionally. This could suggest businesses are not directing credit toward sustainable and environmentally friendly projects, potentially due to economic priorities or regulatory challenges.

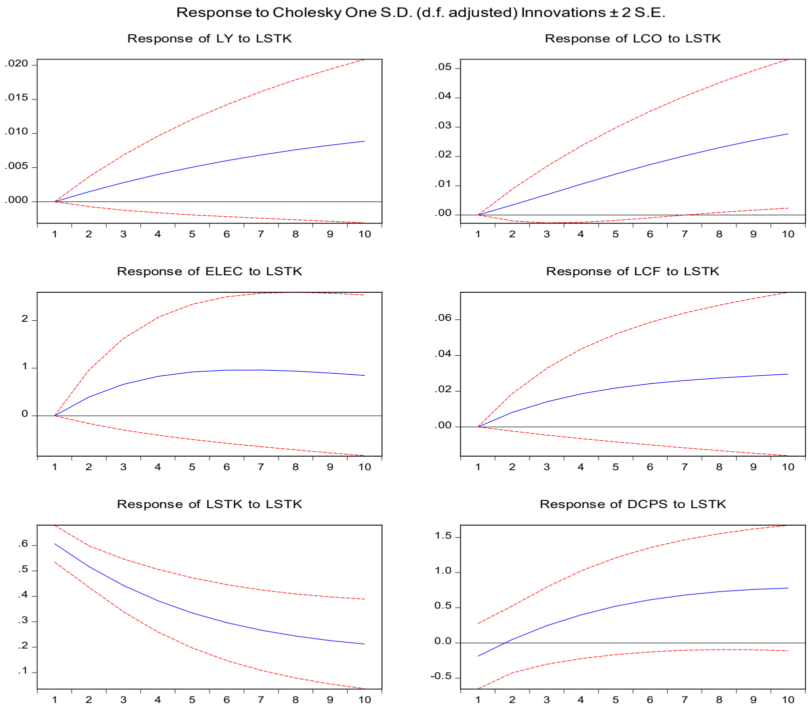


Figure 9. Response to Stock Exchange Shock.

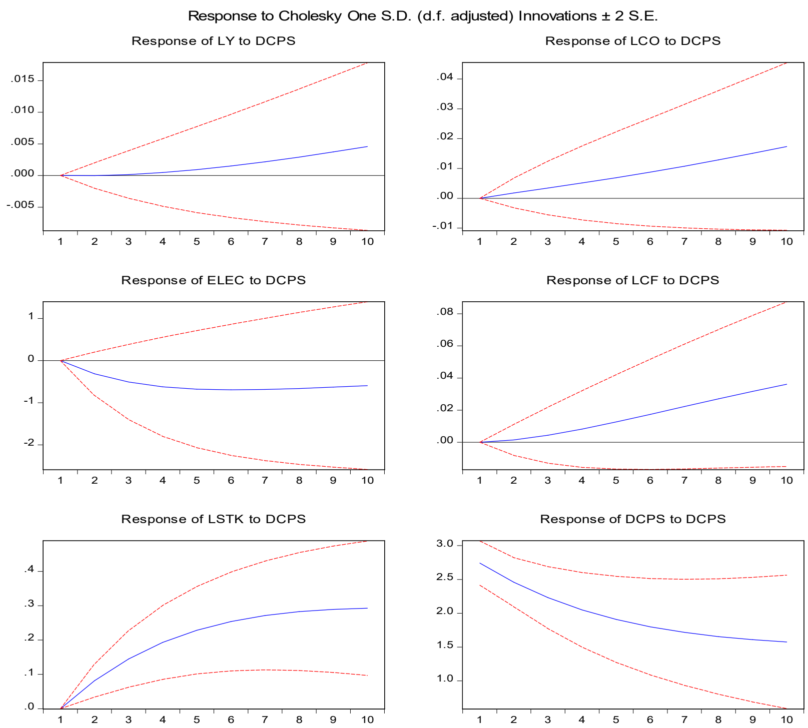


Figure 10. Response to Domestic-Credit-to-Private Sector.

4.4. Long run Analysis

For brevity, we have used three models to find the long-run implications of our model. Table 2 shows that carbon emissions negatively affect output growth in the long run, suggesting a need for sustainability. All other coefficients are as expected. Green energy, investment, stock exchange value, and domestic credit contribute positively to economic development.

For the environmental model, green energy helps reduce carbon emissions in the long run. Investment, GDP, Stock exchange values, and credit increase the pollution in the south Asian countries. The long-term effect of GDP on green energy and carbon emissions is positive, indicating a delayed response by investors to environmental concerns. Table 3 shows that the error correction term is negative for all three models, indicating a possibility of convergence in the developing countries. In the short run, the dynamics of impact change in magnitude and, in some cases, in directions. In the short run, the stock market's effect is negative on GDP and CO2 emissions, contrary to what we observed in the long run. Similarly, the impact of GDP on CO2 is negative, and green energy is positive. In the short run domestic credit reduce the production of green energy.

Table 2. Long-run stable Coefficients.

Variables	Output Model	Environment Model	Energy Model
LY	--	1.995	-58.670
LCO	-0.501	--	29.414
ELEC	0.017	-0.034	
LCF	0.492	0.981	28.867
LSTK	0.039	0.078	2.303
DCPS	0.012	0.024	0.717

Note: All the parameters are statistically significant at most at 10%.

Table 3. Short run Dynamics and Error Corrections.

Variables	Output Model	Environment Model	Energy Model
LY	--	-0.008	
LCO	-0.019	--	0.001
ELEC	2.413	0.742	--
LCF	0.021	-0.014	0.005
LSTK	-0.277	-0.024	0.001
DCPS	1.021	0.303	-0.011
ECT	-0.036	-0.31	-0.252

Note: All the parameters are statistically significant at most at 10%.

5. Conclusions and Implications

This study explores the link between financial advancement, macroeconomic fluctuations, and sustainable energy production in South Asia. It evaluates existing research, identifies gaps, and suggests future directions. Key indicators include per capita GDP, CO2 emissions, electricity generation, stock market prices, GFCF, and credit. The study emphasizes the need to understand how economic activities influence the environment and how environmental factors impact economic and financial outcomes. It also examines financial market responses to understand the manifestation of economic and environmental factors.

Understanding the dynamics of alternative energy price fluctuations is crucial for market participants, especially environmentally conscious investors, to navigate exposure and comprehend the underlying factors. Policymakers are crucial in mitigating risk from volatile asset types. Negative reactions to green energy by investment suggest that investments may not be strategically directed towards cleaner, more sustainable energy sources, posing concerns for long-term environmental and energy security objectives. Variations in responses across economic indicators may indicate policy challenges or structural issues, necessitating a reassessment of government policies to incentivize sustainable investments and promote green technology adoption.

These results imply that policymakers should precisely assess the environmental ramifications of economic growth and stock market activities. This presents an opportunity to craft policies that guide investments toward cleaner technologies and industries, aligning economic growth with sustainable practices. A comprehensive empirical analysis, considering the unique circumstances of each South Asian economy, such as economic structures, policy frameworks, and environmental awareness levels, is essential. The study suggests that the relationship between the region's stock market, GDP, carbon emissions, and green energy is complex, with a negative response to domestic credit indicating potential obstacles to investment, such as policy barriers or insufficient incentives. Mixed responses highlight the need for credit for sustainable projects, suggesting policymakers and financial institutions should explore ways to incentivize green energy investments and promote sustainable economic growth. For future research, it is important to conduct a detailed empirical analysis and consider the region's specific economic and policy contexts to validate these interpretations. Additionally, examining the effectiveness of existing environmental policies and the role of financial institutions in promoting sustainable practices would contribute to a more comprehensive understanding.

Appendix

These VAR residuals show the high volatility in VAR residuals with blue arrows in each graph.

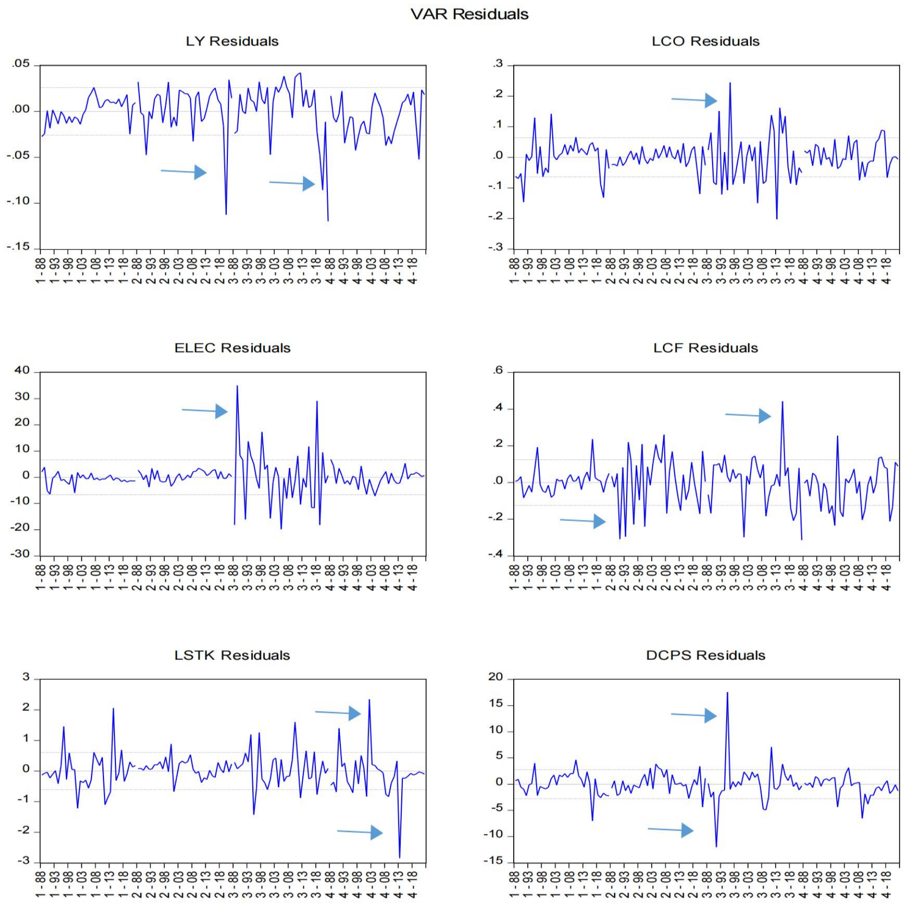


Figure A1. Estimated SVAR Residuals.

Funding Statement

This research received no external funding.

Conflict of interest

All the author claims that the manuscript is completely original. The author also declares no conflict of interest.

References

Acemoglu, D., Aghion, P., Bursztyn, L., & Hemous, D. (2012). The environment and directed technical change. *American Economic Review*, 102(1), 131-166. http://dx.doi.org/10.2139/ssrn.1668575

Amuakwa-Mensah, F., & Nässtrröm, E. (2022). Role of banking sector performance in renewable energy consumption. *Applied Energy*, 306, 118023. https://doi.org/10.1016/j.apenergy.2021.118023

Ang, B. W. (2004). Decomposition Analysis for Policymaking in Energy: Which is the preferred method? *Energy Policy*, 32 (9), 1131-1139. https://doi.org/10.1016/S0301-4215(03)00076-4

Ang, J. B. (2019). Financial development, renewable energy, and economic growth in Malaysia. *Renewable Energy*, 133, 685-692.

Apergis, N., & Payne, J. E. (2010). Renewable Energy Consumption and Economic Growth: Evidence from a Panel of OECD Countries. *Energy Policy*, 38 (1), 656-663. https://doi.org/10.1016/j.energy.2022.123559

Bassi, A. M., & Van Sinderen, J. (2007). Climate Policy and the Sustainable Development of Renewable Energy in Brazil: The Role of Finance. *Energy Policy*, 35 (1), 531-543.

Broadstock, D. C., & Filis, G. (2014). Oil price shocks and stock market returns: New evidence from the United States and China. *Journal of International Financial Markets, Institutions and Money*, 33, 417-433. https://doi.org/10.1016/J.INTFIN.2014.09.007

Brunnermeier, M., & Landau, J. P. (2022, October). Finance, money, and climate change. In 74th Economic Policy Panel Meeting.

Can, M., Balsalobre-Lorente, D., Adedoyin, F. F., & Mercan, M. (2023). The impact of trade openness, export concentration, and economic complexity on energy demand among G7 countries. *Energy & Environment*, 0958305X231177740. http://dx.doi.org/10.1177/0958305X231177740

Cherp, A., & Jewell, J. (2014). The concept of energy security: Beyond the four As. *Energy policy*, 75, 415-421. https://doi.org/10.1016/j.enpol.2014.09.005

Creti, A., Joets, M., & Mignon, V. (2014). Oil price news and stock price movements. *Energy Economics*, 42, 369-378.

Degiannakis, S., Filis, G., & Kizys, R. (2014). The effects of oil price shocks on stock market volatility: Evidence from European data. *Energy Journal*, 35(1), 35-56. https://doi.org/10.5547/01956574.35.1.3

Dell, M., Jones, B. F., & Olken, B. A. (2008). Climate change and economic growth: Evidence from the last half century (No. w14132). National Bureau of Economic Research.

Doda, B., et al. (2015). The Unintended Consequences of Industrial Action on Energy Policy: Evidence from Germany. *Ecological Economics*, 110, 1-8.

Du, L., Wei, C., & Wei, C. (2020). Financial development and renewable energy in Asia: A panel data analysis. *Energy Reports*, 6, 1312-1318. https://doi.org/10.1016/j.eneco.2024.107368

Ghosh, S., & Kanjilal, K. (2016). Oil price shocks, monetary policy, and aggregate demand in the United States. *Energy Economics*, 53, 1-7.

Huang, Y., Zhang, L., & Yang, S. (2019). Financial development and renewable energy: A review. *Renewable and Sustainable Energy Reviews*, 109, 576-589.

Juszczyk, O., Juszczyk, J., Juszczyk, S., & Takala, J. (2022). Barriers for renewable energy technologies diffusion: Empirical Evidence from Finland and Poland. *Energies*, 15(2), 527. https://doi.org/10.20944/preprints202112.0524.v1

Khan, I., Hou, F., Zakari, A., Irfan, M., & Ahmad, M. (2022). Links among energy intensity, non-linear financial development, and environmental sustainability: New evidence from Asia Pacific Economic Cooperation countries. *Journal of Cleaner Production*, 330, 129747. https://doi.org/10.1016/j.jclepro.2021.129747

Kim, J., & Park, K. (2016). Financial development and deployment of renewable energy technologies. *Energy Economics*, 59, 238-250. https://doi.org/10.1016/j.eneco.2016.08.012

Kocaarslan, I., & Soytas, U. (2019). The impacts of oil price changes on clean energy stocks: Evidence from the MENA region. *Energy Economics*, 80, 675-686. https://doi.org/10.1016/j.energy.2020.117099

Kumar, S., Managi, S., & Matsuda, A. (2012). Stock prices of clean energy firms, oil prices, and climate policy. *Energy Policy*, 40, 62-71.

Liu, Y., & Zhang, S. (2017). The impact of economic cycles on renewable energy: A case study of Asian countries. *Energy*, 118, 649-659. https://doi.org/10.1016/j.envres.2020.109567

Lütkepohl, H. (2006). Structural vector autoregressive analysis for cointegrated variables. *Allgemeines Statistisches Archiv*, 90, 75-88. http://dx.doi.org/10.1007/3-540-32693-6_6

Ma, Y., Chen, Z., Mahmood, M. T., & Shahab, S. (2022). The monetary policy during shocks: an analysis of large Asian economies' response to COVID-19. *Economic research-Ekonomska istraživanja*, 35(1), 1862-1883.

https://doi.org/10.1080/1331677X.2021.1926304
Managi, S., & Okimoto, T. (2013). Does the price of oil interact with clean energy prices in the stock market? *Journal of Japanese and International Economies*, 27, 62-73. https://doi.org/10.1016/j.japwor.2013.03.003
Miketa, A., & Schrattenholzer, L. (2004). *Experiences with Long-Term Energy Scenarios. *Technological Forecasting and Social Change*, 71 (3), 271-290.
Müller, A., & Schmidt, T. S. (2020). Renewable Energy and the Political Economy of Resource Curse: The Case of Bioenergy in Germany. *Energy Policy*, 137, 111140.
Obobisa, E. S. (2022). Achieving 1.5 C and net-zero emissions target: The role of renewable energy and financial development. *Renewable Energy*, 188, 967-985. https://doi.org/10.1016/j.renene.2022.02.056
Sardorsky, P. (2008). Oil prices and stock markets. *Energy Economics*, 30 (3), 1011-1026. https://doi.org/10.1093/rof/rfw071
Sethi, P., Chakrabarti, D., & Bhattacharjee, S. (2020). Globalization, financial development and economic growth: Perils on the environmental sustainability of an emerging economy. *Journal of Policy Modeling*, 42(3), 520-535. https://doi.org/10.1016/j.jpolmod.2020.01.007
Shahab, S., & Mahmood, M. T. (2013). Identification of monetary policy shocks: Measurement and effectiveness of the monetary policy shocks. LAP LAMBERT Academic Publishing.
Stern, N. H. (2007). The economics of climate change: the Stern review. cambridge University press.
Sun, Z., Zhang, X., & Gao, Y. (2023). The Impact of Financial Development on Renewable Energy Consumption: A Multidimensional Analysis Based on Global Panel Data. *International Journal of Environmental Research and Public Health*, 20(4), 3124. https://doi.org/10.3390/ijerph20043124
Tang, T. C. (2018). The impact of economic growth, trade openness, and financial development on renewable energy: Empirical evidence from GMM-based panel quantile regression of developing Asian countries. *Energy Economics*, 75, 1-11.
Wang, Y., Zou, C., & Qiao, Y. (2021). Financial development, renewable energy, and economic growth in Asia: Evidence from panel data. *Sustainability*, 13(2), 651.
Wei, Y., Zhang, J., Chen, Y., & Wang, Y. (2022). The impacts of El Niño-southern oscillation on renewable energy stock markets: Evidence from quantile perspective. *Energy*, 260, 124949. https://doi.org/10.1016/j.energy.2022.124949
Zhang, L., Zhou, Y., & Yang, S. (2018). Financial development and renewable energy in China: A review of the literature. *Renewable and Sustainable Energy Reviews*, 81(Part 1), 1712-1721.