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Nexus between Green Investment, Fiscal Policy, Environmental Tax, Energy Price, Natural Resources, and Clean Energy—A Step towards Sustainable Development by Fostering Clean Energy Inclusion

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Abstract: This study aims to examine the relationship between green investment (GI), fiscal policy (FP), environmental tax (ET), energy price (EP), natural resource rent (NRR), and the consumption of clean energy (CE) to promote sustainable development in Cambodia for the period 1990–2021. The study implemented linear and nonlinear frameworks to document explanatory variables' potential effects on clean energy consumption in the long and short run. The research findings demonstrate a robust and favorable connection between GI, FP, ET and CE, both in the long term and short term. An augmentation in GI results in the establishment of sustainable growth in the utilization of renewable energy, thereby underscoring the significance of green initiatives in advancing clean energy technologies. Fiscal policies, encompassing tax incentives and subsidies, exert a substantial and enduring influence on expanding renewable energy sources. Implementing environmental taxes catalyzes the demand for clean energy, significantly preserving the environment and promoting sustainable energy practices. Furthermore, the study illuminates the inverse correlation between oil prices and REC. Adopting renewable energy sources may face obstacles in the form of elevated oil prices, as conventional energy sources maintain a cost advantage. On the contrary, decreased oil prices and natural resource rent incentivize transitioning towards using clean energy. Countries that heavily depend on the export of natural resources may display a reduced inclination to invest in renewable energy, commonly called the "resource curse" phenomenon. This study provides valuable insights into the intricate interplay of multiple factors that influence renewable energy consumption and contribute to sustainable development. Policymakers, businesses, and researchers can employ these findings to develop productive strategies that advance the inclusion of clean energy, tackle potential challenges, and cultivate a more environmentally friendly and sustainable future.

Keywords: green investment; clean energy; fiscal policy; environmental tax; natural resources; energy price

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1. Introduction

Using clean energy is of utmost importance for sustainable long-term development, as it effectively mitigates the release of greenhouse gas emissions that are known to be significant contributors to climate change. Climate change presents a substantial peril to attaining sustainable development through its capacity to induce heightened occurrences of severe weather, elevate sea levels, and engender various other environmental concerns [1–4]. The United Nations Sustainable Development Goals (SDGs) comprise 17 targets designed to eradicate poverty, protect the environment, and promote prosperity for all individuals. Goal 7 of the Sustainable Development Goals (SDGs) aims to ensure universal access to affordable, reliable, sustainable, and modern energy for all individuals [5–9]. This objective underscores the importance of clean energy in the context of sustainable long-term development. Clean energy encompasses various forms, such as solar, wind, hydro, geothermal, and nuclear. Due to the absence of greenhouse gas emissions, these energy sources exhibit a significantly higher level of environmental friendliness than fossil fuels, namely coal, oil, and natural gas.

Using clean energy can enhance air quality, foster job creation, and drive economic growth while concurrently reducing greenhouse gas emissions. Solar and wind energy, for instance, serve as substantial sources of employment opportunities, concurrently mitigating our reliance on imported oil. The transition towards clean energy poses considerable challenges, but sustainable long-term economic growth remains imperative. We must allocate resources towards advancing clean energy research and development while concurrently streamlining the process for corporations and individuals to seamlessly adopt clean energy practices [10–14].

Clean energy has emerged as a major force in defining the global landscape, assuming unprecedented significance due to its profound implications for sustainable development, environmental preservation, and energy security [15]. Adopting renewable energy (RE, hereafter) sources, such as solar, wind, hydro, geothermal, and biomass, has become necessary to transition to a low-carbon economy in light of the global challenges posed by climate change and diminishing fossil fuel reserves [1]. In addition to mitigating greenhouse gas emissions and reducing pollution, clean energy offers a multifaceted approach that stimulates economic development, fosters technological innovation, improves energy efficiency, empowers communities, and fosters international cooperation [16]. Adopting sustainable energy globally is not merely an option but a fundamental necessity, paving the way for future generations' resilience and prosperity. At the core of the significance of RE is its capacity to mitigate the devastation brought on by climate change [17]. Greenhouse gas emissions, predominantly from the combustion of fossil fuels, have caused global warming, which has resulted in rising sea levels, extreme weather events, and ecosystem disruptions [18]. Clean energy (CE, hereafter) technologies fueled by renewable sources are crucial for reducing these emissions, contributing to the global effort to limit temperature rise and reduce the risk of catastrophic climate consequences. By shifting away from carbon-intensive energy sources, nations can collaborate to achieve the goals outlined in international agreements such as the Paris Agreement, nurturing a collective response to a shared global challenge. In addition, RE catalyzes sustainable development, thereby transforming economies and industries [19]. RE technologies have undergone tremendous advancements, making them increasingly competitive with traditional sources. RE solutions offer substantial economic benefits, including job creation, investment attraction, and economic expansion [20]. As a result of research and development in the RE sector, advancements have been made in energy efficiency, energy storage, and grid management. Investing in clean energy promotes economic diversification, reduces reliance on volatile fossil fuel markets, and positions nations at the vanguard of the emerging green economy. In addition to its economic benefits, RE also improves energy security by decreasing reliance on imported fossil fuels [21]. Numerous nations are vulnerable to geopolitical risks and price fluctuations associated with imports of fossil fuels, which can destabilize economies and compromise national security. Adopting RE domestically provides a means to diversify energy sources, increase energy independence, and lessen sensitivity to supply disruptions [22,23].

The present study has considered green investment (GI, hereafter), fiscal policy (FP, hereafter), environmental tax (ET, hereafter), oil price (OP, hereafter), and natural resource rent (NR, hereafter) in the equation of clean energy consumption (CEC, hereafter). Investments in green initiatives have the potential to foster the advancement and widespread adoption of sustainable energy technologies [24]. Governments and companies have the potential to facilitate the transition towards a more sustainable energy system through their investments in renewable energy sources such as solar and wind power. Additionally, green investments can enable renewable energy companies to expand their operations, promoting the wider adoption of clean energy [25]. Fiscal policies have the potential to make a substantial contribution toward reducing energy poverty and promoting energy efficiency. Some examples encompass public funding and tax refunds [25]. Governments can promote the adoption of clean energy technology by providing incentives, such as tax credits for investments in renewable energy [26]. Additionally, fiscal policies can play a crucial role in facilitating the growth of clean energy enterprises and the development of clean energy infrastructure [27,28]. Environmental taxes can encourage the adoption of clean energy technologies by raising the cost of non-renewable energy sources [29]. Environmental taxes can potentially incentivize sustainable energy sources such as solar and wind power by augmenting the expenses associated with fossil fuels, leading to increased utilization of renewable energy sources and a subsequent reduction in greenhouse gas emissions. Non-renewable energy sources directly impact the cost of clean energy sources, resulting in increased consumer interest and subsequent consumption of clean energy. However, in cases where non-renewable energy sources are more cost-effective, the profitability of clean energy sources may be reduced, leading to a decrease in the utilization of clean energy. The adoption of clean energy technologies may be influenced by the availability of natural resources, including wind, sun, and hydropower. In certain instances, nations possessing a surplus of natural resources may exhibit a greater propensity to engage in such activities, thereby increasing the utilization of renewable energy sources.

The study contributes significantly to comprehending the factors influencing REC and promoting sustainable development. The findings demonstrate a strong and favorable correlation between GI and the utilization of RE, both in the long term and short term. This underscores the significance of augmenting investments in RE initiatives, such as wind farms and solar installations, to foster a sustainable energy landscape for the future. The findings above align with the current body of literature that underscores the significance of green initiatives in facilitating the uptake of clean energy technologies [20,30–35]. However, it is imperative to thoroughly evaluate the implementation challenges and barriers that could impede the effective execution of GI initiatives. Research conducted by several scholars has highlighted the significance of securing sufficient funding, addressing technological feasibility, and establishing supportive regulatory environments to guarantee the success of RE projects. Furthermore, the study elucidates fiscal policy's noteworthy influence in fostering RE consumption. The presence of positive and statistically significant coefficients about fiscal policy, both in the long run and short run, emphasizes the efficacy of measures such as tax incentives, subsidies, and grants in fostering the growth of RE sources. Similar conclusions have been drawn in the works of [36], who emphasize the positive impact of fiscal policies in stimulating the adoption of RE. However, it is imperative to meticulously evaluate the potential trade-offs and unintended consequences of fiscal policies. As highlighted by [37], excessive dependence on subsidies and grants can exert pressure on government budgets and introduce market distortions, thereby impacting the long-term viability of RE initiatives.

The study underscores the environmental ramifications associated with implementing environmental taxes. The positive and statistically significant impact of environmental taxes on the utilization of RE in both the long and short term highlights the potential of implementing these taxes as a means of environmental preservation and promoting the integration of RE sources into the economy. Nevertheless, it is imperative to thoroughly evaluate the design and execution of environmental taxes to ascertain their efficacy in stimulating demand for clean energy while preventing an undue burden on low-income households or impeding overall economic progress. The research underscores the significance of meticulously crafting environmental tax policies to achieve a harmonious equilibrium between environmental objectives and socio-economic factors [38–41].

The remaining structure is as follows. The literature review and hypothesis development are exhibited in Section 2, the theoretical development of the study is explained in Section 3, and the data and methodology of the study are available in Section 4. In addition, Section 5 deals with the estimation and interpretation of the results. The discussion conclusion and policy suggestions are reported in Sections 6 and 7, respectively.

2. Literature Survey

2.1. Green Investment and Clean Energy Consumption

Several studies have examined the relationship between green investment and renewable energy consumption. It has been discovered that green finance stimulates a shift in energy consumption from fossil fuels to renewables by encouraging investment in sustainable energy [15,17,19,21,42]. For instance, in the case of China, the study [43] established that FinTech and green finance prompt green economic growth by expediting clean energy in the energy mix. Additionally, for African nations, the study [44] advocated the critical role of green finance and FinTech adaptation for the inclusive energy transition. Ref. [45] exposed the development of Financial Technology (FinTech), which has been observed to have a positive influence on the consumption of renewable energy resources (REC) while simultaneously discouraging carbon emissions (CE). Additionally, it has been noted that economic growth has a beneficial effect on reducing carbon emissions (CE). This study underscores the significance of embracing financial technology as a crucial measure to mitigate and prevent additional environmental degradation.

Green investment has been found to positively affect clean energy consumption, encouraging consumers and producers to adopt clean energy sources and positively affecting environmental quality [46]. It has also been shown to reduce CO2 emissions, contributing to environmental sustainability [47]. Green fiscal policies, such as public support and tax rebates, significantly reduce energy poverty and promote energy efficiency. Additionally, green finance has been identified as a bridge to renewable energy deployment, promoting the implementation of green projects. Overall, green investment has a crucial role in promoting clean energy consumption and mitigating environmental pollution [48].

A sustainable environment and economic growth can be achieved by using sustainable resources and green investments in the economic sectors. It has been determined that expanding green bonds substantially promotes renewable energy investment and decreases environmental pollution. The study [6,49] discovered that green finance positively affects green energy initiatives, particularly small-scale energy investments. The influence of green financial development, such as green credit, investment, and securities, on renewable energy consumption has also been studied. The literature suggests that green investment can positively affect clean energy consumption by promoting the adoption of renewable energy sources and fostering sustainable economic growth. However, contradictory findings have been reported regarding the relationship between green finance and the use of renewable energy in countries with varying income levels [50].

Another line of evidence dealing with GI's effects on environmental development is that GI fosters environmental sustainability by reducing excessive CO_2 emissions [2,4,5,16,23,51,52]. For instance, in the case of China, Wan and Sheng [53] examined a simultaneous equation and demonstrated that green infrastructure (GI) positively impacts REC and economic development without contributing to increased CO_2 emissions. Using the autoregressive distributed lag (ARDL) method, Zahan and Chuanmin [54] advocated that green infrastructure is essential for fostering the long-term adoption of RE sources and mitigating the negative effects of carbon dioxide (CO_2) emissions.

The existing body of literature indicates that green investment is pivotal in promoting clean energy consumption, mitigating carbon emissions, and cultivating sustainable economic growth. This statement underscores the significance of implementing supportive policies, financial mechanisms, and government interventions to facilitate the transition towards a more environmentally friendly and sustainable energy system.

Hypothesis 1: *Green investment arguments for clean energy development.*

2.2. Fiscal Policy and Renewable Energy Consumption

Multiple research endeavors have consistently revealed a compelling correlation between fiscal policies and adopting clean energy solutions (Zhao, et al. [55]; Chang et al. [56]. Ike, Usman and Sarkodie [22]). For instance, in the case of BRIC, Li et al. [57] investigated the impact of fiscal and environmental policies on carbon emissions from 1990 to 2019. The study uncovered a positive relationship between economic growth, non-renewable energy consumption, government expenditures, and carbon emissions. On the other hand, it was discovered that taxation revenue, environmental policies, and the incorporation of renewable energy sources effectively mitigate carbon footprints. In another study, Mazina, Syzdykova, Myrzhykbayeva, Raikhanova and Nurgaliyeva [9] examine the potential effectiveness of Green Fiscal Policy in harmonizing pricing mechanisms and mobilizing resources to address climate change and advance sustainability.

Additionally, Chang et al. [58] analyze the interplay between subsidies, tax rebates, and research and development (R&D) policies and their impact on the market valuation of Chinese renewable energy companies. The study presented a noteworthy inverted U-shaped correlation between government subsidies and market value, particularly when combined with R&D investment. The authors emphasized the significant influence of policy incentives on shaping the market's perception of the feasibility of renewable energy. For the USA, Jamil et al. [59] assessed the influence of uncertainties in monetary, fiscal, and trade policies on renewable energy production for 35 years. The study revealed that fiscal policy uncertainty enhances renewable energy generation, whereas monetary policy uncertainty impedes it.

The study of [52] underscores the significance of maintaining transparency regarding objectives and accurately assessing fiscal impacts while implementing reform strategies. The finding emphasizes the potential of energy tax and subsidy reform in effectively promoting sustainable development and mitigating greenhouse gas emissions. Additionally, it demonstrates that government subsidies and tax rebate policies substantially positively influence the pure productivity and innovation of renewable energy firms. This statement highlights the significance of green fiscal policies in fostering green investment and enhancing productivity. The study of [24] reveals that green fiscal policies, such as providing public support and tax rebates, are crucial in mitigating energy poverty and fostering energy efficiency. Renewable energy companies significantly improved net fiscal competence and size efficiency.

Moreover, their levels of energy efficiency surpassed the threshold of 0.457%. This achievement can be attributed to the combined effect of current public supports, accounting for 16%, and taxation rebates, contributing 11%. These measures have played a crucial role in reducing energy poverty by 29.7% across various international economies. The study of [25] emphasizes the significance of expanding private investment in renewable energy to decarbonize the global economy and facilitate a low-carbon transformation. It underscores the importance of implementing fiscal and financial policies that facilitate the mobilization of green finance and green investment. The study of [50] highlights the significance of green fiscal policies in fostering energy efficiency and mitigating greenhouse gas emissions. This statement underscores the potential negative consequences associated with the free-riding and excessive allocation of subsidies towards green investments. It also emphasizes the importance of reducing subsidies to safeguard the overall well-being of green investment initiatives [60].

It can be stated that fiscal policy plays a pivotal role in facilitating the advancement of clean energy development. Green fiscal policies, including public support, tax rebates, and subsidies, have substantially influenced renewable energy companies' productivity, innovation, and efficiency. Governments and industries ought to give precedence to the implementation of fiscal policies that facilitate the unlocking of green finance and green investment to attain sustainable development goals and foster a cleaner and more resilient future [46].

Hypothesis 2: *Fiscal Policy prompts clean energy inclusion in the economy.*

2.3. Environmental Tax and Clean Energy/Renewable Energy Consumption

Multiple studies have connected environmental taxation and promoting renewable energy sources, such as those by Sharif et al. [61] and Abbas et al. [62]. For example, Alola et al. [63] conducted a comprehensive study on the environmental tax co-benefits in the agricultural economies of France, Germany, Italy, and Spain from 1995 to 2020, employing MMQR. The study exposed how environmental taxes positively impact environmental sustainability and agricultural value within the "Big Four" nations. Furthermore, Yasmeen, Zhang, Tao and Shah [29] delve into energy efficiency within the OECD, exploring the utilization of green technologies, the implementation of environmental taxation, and the management of natural resources. The study unveiled that the environmental tax and adoption of green technologies have a positive impact on energy efficiency, productivity, and intensity. A similar vine of findings can be derived from the study of Sharif et al. [64], Shayanmehr et al. [65], Yunzhao, L [66], Wolde-Rufael and Mulat-Weldemeskel [67], Bilan et al. [68], Niu et al. [69], Tu and Wang [70].

For the case of China, Xi and Yao [71] utilized provincial panel data spanning from 2003 to 2019, which has shown to have a significant positive impact on the economies of developed nations. The research findings indicate that administrative legislation hinders renewable energy development and economic growth. In contrast, market-based environmental regulation proves beneficial, suggesting that Chinese policies should be implemented to achieve a harmonious equilibrium between economic growth and environmental preservation. In another study, Fang et al. [72] investigated the utilization of ET and RE in 15 countries along the BRI spanning from 1998 to 2019. They demonstrated that exposed ET exhibits a negative impact on REC in the short term. A similar domain of research findings was established by Chien et al. [73], Hao et al. [74] and Bashir, et al. [75].

Taking into account carbon neutrality, Niu, et al. [76] and Hsu, et al. [77] used data from 1980 to 2018 to show that ecological innovation, renewable energy (RE), and the implementation of environmental taxes have proven to be effective measures in reducing carbon dioxide (CO_2) emissions in China. Additionally, Dogan, et al. [78] offset the aligned evidence for the EU.

In summary, the literature suggests that implementing environmental taxes can diminish greenhouse gas (GHG) emissions and encourage the utilization of renewable energy sources. However, it is crucial to note that the efficacy of these environmental taxes in curbing carbon dioxide (CO_2) emissions is contingent upon the specific nature of the tax and the prevailing level of energy consumption within a given country. Additionally, it is worth mentioning that environmental taxes can contribute to elevated prices of fossil fuels, thereby resulting in a decrease in demand for such fuels and a corresponding shift towards renewable energy alternatives. Furthermore, it is important to acknowledge that environmental taxes can also play a role in reducing energy demands through the implementation of progressive energy efficiency measures. Moreover, the association between environmental taxes and renewable energy consumption is subject to the influence of various other factors, including but not limited to environmental technologies, the environmental stringency index, and environmental expenditures. Thus, it can be argued that implementing environmental taxes can serve as a viable and productive policy tool to mitigate greenhouse gas (GHG) emissions and foster the adoption of clean and renewable energy sources. The effectiveness of environmental taxes, however, is contingent upon many factors, including but not limited to the specific nature of the tax, the extent of a nation's energy consumption, and additional environmental and economic indicators.

Based on the literature, the following hypothesis has been formulated.

Hypothesis 3: *Environmental tax is positively connected to clean energy consumption.*

2.4. Energy Price and Clean Energy/Renewable Energy Consumption

A compelling body of evidence from various studies and research endeavors demonstrates a positive and robust bond between energy prices and clean energy (Zhou, et al. [79], Lv, et al. [80], Kazemzadeh, Fuinhas, Koengkan and Shadmehri [33], Fahmy [8] and Alkathery, et al. [81]). For instance, Sarker, Bouri and Marco [32] and Geng, et al. [82] examine how crude oil prices affect European clean energy firms' stock returns. Oil returns operate as a net information receiver in the crude oil–clean energy nexus system, following oil price fluctuations. The study also indicates that crude oil returns and RE company returns are highly interdependent and stable across time. According to the study, bad news affects information connection more than positive news. These findings affect clean energy policymakers and market actors.

Xia, et al. [83] use a network technique to explore how fossil energy price fluctuations affect RE stock returns. The study creates positive and negative return networks and a value-at-risk (VaR) web to uncover asymmetric and extreme information spillovers. The fossil energy–RE network system shows a high level of interconnectedness. In the returns connectedness network, the electricity market drives RE returns, but in the VaR network, oil and coal drive the returns. Dynamic results show considerable volatility in fossil energy price contributions to RE profits. Throughout the study period, the positive returns network had more connectedness than the negative ones. The analysis helps investors and regulators understand the complicated relationships between fossil and RE industries. Reboredo and Ugolini [84] use a multivariate vine-copula dependence design to examine how quantile oil, gas, coal, and power price fluctuations affect clean energy stock returns. Oil and power costs drove clean energy stock returns in the US and EU from 2009 to 2016, but other energy prices had little effect. Extreme energy price changes affect clean energy stock returns symmetrically. These findings affect energy investors' risk management and regulators' clean energy implementation decisions. A multivariate article by Bondia, et al. [85] explores the long-term relationship between alternative energy stock values and oil prices, taking structural breaks into account. The study finds threshold cointegration with two endogenous structural fractures, contradicting a previous study that overlooked them. Alternative energy stock prices, technology stock prices, oil prices, and interest rates have short-term correlations but no long-term causality. The report explains these facts and offers investors short- and long-term investment potential. However, a study opposes the above findings [54].

It is important to note that rising crude oil prices do not necessarily facilitate an immediate increase in renewable energy consumption. However, it is worth mentioning that once a certain threshold level of crude oil price is reached, it is likely that further increases in oil prices will have a positive impact on the figures related to renewable energy consumption. The impact of oil prices on renewable energy consumption is subject to the influence of various other factors, including but not limited to the level of energy consumption within a given country, the prevailing environmental policies, and the prevailing economic indicators [86]. Additionally, it is important to note that the fluctuations in oil prices do not solely determine the influence of oil prices on renewable energy consumption. Other factors, such as environmental policies and economic indicators, also significantly shape this relationship. Based on the given literature, the following hypothesis has been developed.

Hypothesis 4: *There is an adverse association between oil prices and clean energy.*

2.5. Natural Resources and Clean Energy/RE Consumption

The interconnection and significance of the relationship between natural resources and clean energy are noteworthy. Clean energy sources, including solar, wind, hydro, and geothermal power, depend on the accessibility and effective utilization of natural resources. Renewable energy sources present a viable and sustainable alternative to fossil fuels, which possess finite reserves and are known to contribute significantly to environmental degradation. Using natural resources, clean energy technologies can produce electricity while minimizing the release of greenhouse gas emissions, which has the potential to decrease our dependence on non-renewable resources and effectively address the issue of climate change. Thus, there is a positive link between natural resources and clean energy [55–57,87]. For instance, Liu, Baisheng, Alharthi, Hassan and Hanif [41] assess natural resources, clean energy generation, and technological improvement in limiting carbon emissions employing CS-ARDL econometric data from 14 populous nations from 1990 to 2019. Various studies have concluded that clean energy and technological innovation reduce carbon emissions and improve environmental quality. In contrast, high reliance on natural resources for rent degrades it. The study implies that abundant green natural resources and efficient utilization can protect the environment despite significant population pressure. Clean energy generation and technical advancements are essential to reaching carbon neutrality targets in densely populated countries, as demonstrated by the findings available in the work of Wang, Zhang and Li [30], Usman and Balsalobre-Lorente [88], and Yu, et al. [89].

Moreover, Shaheen, Lodhi, Rosak-Szyrocka, Zaman, Awan, Asif, Ahmed and Siddique [90] revealed that green energy consumption and sustainable resource management are essential in managing environmental quality in China. Likewise, Yu, et al. [91] and Awosusi, et al. [92], in the case of Colombia, analyze the nexus between globalization, RE, natural resource rent, economic growth, and CO_2 emissions. The study postulated that it is essential to promote RE development and enhance the environment of RE investment to alleviate environmental deterioration. The same findings can be found in the work of Zhou and Li [34], Jaiswal, et al. [93], and Chau, et al. [94]. Additionally, the studies of Khan, et al. [95], Zhang, et al. [96], and ref. [58] probe the role of natural resources in the inclusion of clean energy.

In sustainable energy, the utilization and advancement of natural resources, namely wind, solar, hydro, geothermal, and biomass, play a pivotal role in facilitating the progress and dissemination of clean energy solutions. The transition from fossil fuel-based energy sources to renewable energy alternatives has been widely recognized as a crucial strategy for mitigating climate change and fostering environmental well-being. Local governments have the potential to serve as exemplary models by implementing various strategies such as on-site energy generation, procurement of green power, or acquisition of renewable energy sources. Utilizing a diverse array of renewable energy alternatives can effectively contribute towards achieving local government objectives, particularly in areas characterized by variations in the accessibility and reliability of renewable resources. Based on the established literature, the following hypothesis has been formulated for the study.

Hypothesis 5: *Natural resources positively influence clean energy consumption.*

3. Theoretical Development and Justification of the Study

This study analyzes the complex and interrelated relationships among GI, fiscal policy, environmental tax, energy price, natural resources, and RE. In light of the pressing global challenges, such as climate change and environmental degradation, it is imperative to grasp the intricate interplay between these factors fully. This understanding is crucial for developing impactful policies and strategies to foster the widespread adoption of RE and promote sustainability [2].

The study's multidisciplinary theoretical framework incorporates environmental economics, energy policy, public finance, and sustainable development concepts. The framework considers the roles and responsibilities of different stakeholders, including governments, businesses, consumers, and international institutions, in shaping the interactions among the identified variables. GI involves strategically allocating financial resources toward projects and initiatives that yield positive environmental outcomes and contribute significantly to the advancement of sustainable development. Clean energy encompasses a range of RE sources, including solar, wind, hydro, geothermal, and bioenergy. These sources have the distinct advantage of leaving minimal environmental footprints and emitting low or no greenhouse gases [59]. The study of theory delves into the interrelationships between GI and the advancement of RE technologies. This paper explores the correlation between heightened investment in clean energy initiatives and the subsequent outcomes of technological advancements, cost reductions, and enhanced market competitiveness for RE sources. Fiscal policy, which governments implement through taxation and expenditure measures, substantially influences economic behavior and resource allocation [60].

The study investigates the impact of fiscal policies, specifically tax incentives, subsidies, and grants, on adopting and utilizing RE technologies. This study examines the efficacy of meticulously crafted fiscal measures in stimulating private sector investments in RE initiatives, fostering energy efficiency, and expediting the shift towards a low-carbon economy. Environmental taxes are imposed on activities or goods that have adverse environmental externalities. The theoretical development delves into the concept of environmental taxation and its capacity to incentivize environmentally friendly practices and the adoption of RE solutions [6]. This study examines the correlation between environmental tax policies and the mitigation of carbon emissions alongside the funding mechanisms for RE ventures and initiatives aimed at environmental conservation. The fluctuations in energy prices, specifically those associated with fossil fuels, can significantly influence the economic feasibility and attractiveness of RE technologies. The present study examines the correlation between energy prices and the adoption rate of RE sources. This study explores the potential influence of fluctuating energy prices on investment choices and the uptake of RE alternatives, with particular emphasis on the significance of price stability in fostering sustainable energy strategies. Oil, gas, minerals, and biomass exemplify natural resources that possess the potential to exert significant influence on energy policy and the ongoing transition toward RE. The theoretical development explores the correlation between the accessibility and utilization of natural resources and their influence on formulating energy diversification strategies and establishing RE infrastructure. This analysis explores the potential role of natural resource rent in financing RE initiatives and promoting energy security.

Governments and the business sector can use this information to strategically utilize GIs as effective economic stimulants. By doing so, it can foster economic growth while simultaneously advancing environmental objectives. Gaining a comprehensive understanding of the effectiveness of fiscal policies, such as tax breaks and subsidies, in promoting the adoption of sustainable energy can assist policymakers in formulating precise and targeted fiscal measures. Well-designed fiscal policies have the potential to attract private investments, foster innovation, and facilitate the growth of clean energy enterprises. These factors collectively contribute to developing a more sustainable and competitive economy. One can suppose that the research highlights the importance of natural resources in influencing energy policy. In that case, policymakers can leverage this information to diversify their energy sources and reduce their dependence on fossil fuels. Diversification enhances energy security by mitigating the potential hazards associated with fluctuating energy expenses and interruptions in supply. The mitigation of externalities can result in diminished healthcare expenses and increased productivity, yielding economic benefits for society.

The environmental consequences of human activities are vast and far-reaching. These consequences can harm ecosystems, biodiversity, and the overall environment. Regarding climate change mitigation, should the research ascertain a positive correlation between GI, fiscal policy, and clean energy adoption, it is plausible that this could significantly contribute to climate change mitigation. The increased utilization of RE sources reduces greenhouse gas emissions, thereby contributing to global efforts in combating climate change. Regarding improved air and water quality, promoting clean energy by implementing fiscal policies and environmental taxes can reduce emissions from fossil fuel-based energy sources, enhancing air and water quality. Improved air and water quality offer immediate environmental benefits, fostering a healthier and more sustainable environment for individuals and ecosystems. A comprehensive understanding of the impact of natural resources on adopting clean energy can potentially aid governments in formulating sustainable policies and mitigating the overexploitation of valuable resources. This measure has the potential to effectively preserve and sustainably manage our finite natural resources, thereby ensuring the protection and preservation of biodiversity. The implementation of effective fiscal policies and the imposition of environmental taxes have the potential to incentivize both businesses and individuals to adopt more environmentally conscious practices. This statement promotes a culture of environmental stewardship and responsibility, resulting in heightened efforts toward sustainable resource management and environmental preservation. The augmentation of GI can foster extensive research and development in clean energy technology, fostering innovative ideas and advancements that enhance the efficiency and affordability of RE sources, thereby facilitating their widespread adoption and utilization.

4. Data and Methodology of the Study

4.1. Model Specification

The following empirical model will be implemented to assess the target empirical nexus.

$$\mathrm{REC} \int \mathrm{FP}, \mathrm{ET}, \mathrm{OP}, \mathrm{NRR}, \mathrm{GI}$$

where REC, FP, ET, OP, NRR and GI stand for REC, fiscal policy, environmental test, oil price, natural resource rent, and GI, respectively.

4.2. Variable Definition

Clean energy can be described as energy sources and technologies with minimal environmental impact, negligible or absent greenhouse gas emissions, and enduring sustainability. Examples include solar, wind, hydropower, geothermal, and biomass [61,62]. Fiscal policy refers to strategic measures that are undertaken by the government, such as taxation and expenditure, to influence economic conditions and achieve policy objectives. In the context of clean energy, fiscal policy can incentivize the adoption of renewable energy sources and discourage using environmentally harmful energy sources [31,63]. Environmental taxes are levies imposed on activities or commodities that harm the environment. The objective is to internalize the external costs of pollution and resource depletion. Environmental taxes incentivize cleaner and more resource-efficient practices. Oil price is the cost of crude oil on the global market. Fluctuations in oil prices have implications for economies, businesses, and energy policy. Higher oil prices can increase the competitiveness of renewable energy technologies. Lower oil prices may make fossil fuels more economically attractive [64,65]. Natural resource rent is the surplus revenue derived from exploiting natural resources, such as oil, gas, minerals, and wood, after subtracting extraction costs. Natural resource rent can finance renewable energy initiatives and facilitate the shift towards sustainable energy sources [57,59,66].

Green investments are investments in initiatives or businesses that are both environmentally beneficial and have a long-term focus, which includes investments in renewable energy, energy efficiency, sustainable infrastructure, and other ecologically beneficial activities. Green investments address environmental concerns while promoting economic development and job creation [4,9,21,29,67–72]. Table 1 displayed the variables definition and data sources.

Table 1. Variables' definitions and data sources.

Variables	Notation	Definition	Expected Result
Clean energy	REC		
Fiscal policy	HP	Fiscal policy is measured using taxation revenue shares of GDP.	+
Environmental tax	ET	Environment protection tax	+
Oil price	OP	Oil price	–
Natural resources	NRR	Natural resource rent	+
Green investment	GI	Measured by investment in the environmental protection products by resident units	+

5. Estimation Strategy

5.1. Unit Roof Test

In the field of time series analysis, unit root tests play a crucial role in assessing the stationarity of a variable. Notably, the Perron and Vogelsang test [73], as well as the Augmented Dickey–Fuller (ADF) test [74], are widely recognized and indispensable statistical tools for this purpose. Typically, the fundamental equation for unit root analyses is as follows:

$$y(t) = \rho * y(t-1) + \varepsilon(t)$$

where y(t) is the variable of interest at time t, ρ is the coefficient of lagged $y(t-1)$, and ε(t) represents the error term.

5.2. Bayer–Hancked and Makki Cointegration

The Bayer–Hancked Combined Cointegration Test [75] is a statistical test employed for evaluating the existence of cointegration among multiple time series variables. Cointegration is an enduring association between non-stationary variables, wherein short-term deviations from the equilibrium are permitted. The basic equation is as follows:

$$y_i, t = \alpha_i + \beta_i * t + \Sigma(g_i * \Delta y_i, t) + \varepsilon_i, t$$

where the variable y_i, t denotes the time series variable i at time t. The symbol α_i represents the intercept that is specific to the variable i. The slope coefficient β_i represents the capturing of any common time trend shared by all variables. The symbol Δy_i, t denotes the first difference of variable i at time t. The coefficient of the first difference of variable i is denoted as g_i. The error term specific to the variable i at time t is represented as ε_i, t.

The Maki cointegration test [76] is a statistical method used to determine the presence of a long-term relationship between two or more time series variables and to assess the existence of cointegration among multiple non-stationary time series variables. The basic equation is as follows:

$$y_t = \alpha + \beta * t + \Sigma(\gamma_i * \Delta y_i, t) + \varepsilon_t$$

where the variable y_t, α, β, Δy_i, t, γ_i denotes the dependent variable at time t, the intercept, the slope coefficient that captures any common time trend that is shared by all variables, the first difference variable i at time t, the first difference in variable i, and the error term, denoted as ε_t, is a crucial component in this context.

5.3. Augmented Autoregressive Distributed Lag

The general form of the ARDL model can be represented as follows:

$$y_t = \beta_0 + \sum(\beta_i * y_{t-i}) + \sum(\gamma_i * x_{t-i}) + \varepsilon_t$$

where y_t is the dependent variable at time t, x_t is the independent variable at time t. β_0 is the intercept term. β_i and γ_i are the coefficients of the lagged levels and differences, respectively. ε_t is the error term.

The Autoregressive Distributed Lag (ARDL) approach allows us to capture both short-term dynamics and long-term equilibrium relationships among the variables. The general form of the ARDL model is as follows:

Long-Run Equation:

$$\begin{aligned} CE_t = \beta 0 &+ \sum(\beta i * CE_{t-i}) + \sum(\beta i * FP_{t-i}) + \sum(\beta i * ET_{t-i}) + \sum(\beta i * OP_{t-i}) \\ &+ \sum(\beta i * NRR_{t-i}) + \sum(\beta i * GI_{t-i}) + \varepsilon_t \end{aligned}$$

Short-Run Equation:

$$\begin{aligned} \Delta CE_t = \alpha 0 &+ \sum(\alpha i * \Delta CE_{t-i}) + \sum(\alpha i * \Delta FP_{t-i}) + \sum(\alpha i * \Delta ET_{t-i}) \\ &+ \sum(\alpha i * \Delta OP_{t-i}) + \sum(\alpha i * \Delta NRR_{t-i}) + \sum(\alpha i * \Delta GI_{t-i}) + \varepsilon_t \end{aligned}$$

where CE_t represents renewable energy consumption at time t. FP_t represents fiscal policy at time t. ET_t represents the environmental tax at time t. OP_t represents the oil price at time t. NRR_t represents the natural resource rent at time t. GI_t represents green investment at time t. ε_t represents the error term.

5.4. Nonlinear Autoregressive Distributed Lagged

The NARDL model can be expressed in the general form as follows:

$$y_t = \alpha + \sum(\beta_i * y_{t-i}) + \sum(\gamma_i * \Delta y_{t-i}) + \sum(\delta_i * |\Delta y_{t-i}|) + \varepsilon_t$$

In this equation, the variable y_t represents the dependent variable at time t. The term α represents the intercept term. The coefficients of the lagged dependent variable y_{t-i} are denoted as β_i. Similarly, the coefficients of the differenced dependent variable Δy_{t-i} are represented by γ_i. The coefficients of the absolute differenced dependent variable $|\Delta y_{t-i}|$ are denoted as δ_i. Lastly, the term ε_t represents the error term.

Numerous subsequent studies have significantly broadened and applied the NARDL model in various fields, such as finance, energy, and environmental economics. Researchers have employed the NARDL model to investigate nonlinear relationships among financial variables, analyze the impacts of oil price shocks on economic variables, and assess the asymmetric responses of REC to changes in environmental legislation.

The study considered a nonlinear framework following the work in empirical assessment for detecting the asymmetric impact of GI, fiscal policy, and environmental tax on clean energy consumption. For gauging the asymmetric effects of GI, FP, and ET on CE, the following generalized equation is to be implemented:

$$CE_t = (\beta^+ GI^+_{1,t} + \beta^- GI^-_{1,t}) + (\gamma^+ FP^+_{1,t} + \gamma^- FP^-_{1,t}) + (\pi^+ ET^+_{1,t} + \pi^- ET^-_{1,t}) + \delta_i X_t + \varepsilon_t$$

where $\beta^+, \beta^- : \gamma^+, \gamma^-$ and π^+, π^- stand for the long-run pavements. The coefficient of β^+ and β^- specifies the effect of positive and negative shocks in GI and γ^+ and γ^- denote the positive and negative effects of FP and π^+, π^- for asymmetric effects of environmental tax on RE. Furthermore, the coefficients of δ_i measure the effects of control variables in the equation.

The asymmetric shock of explanatory variables, i.e., GI^+; G^-, FP^+; FP^-; and ET^+; ET^-, can be derived in the following manner.

$$\begin{cases} POS(EPU)_{1,t} = \sum_{k=1}^{t} lnEPU_k^+ = \sum_{K=1}^{T} MAX(\Delta lnEPU_k, 0) \\ NEG(EPU)_t = \sum_{k=1}^{t} lnEPU_k^- = \sum_{K=1}^{T} MIN(\Delta lnEPU_k, 0) \end{cases} : \begin{matrix} POS(FI)_{1,t} = \sum_{k=1}^{t} lnFI_k^+ = \sum_{K=1}^{T} MAX(\Delta lnFI_k, 0) \\ NEG(FI)_t = \sum_{k=1}^{t} lnFI_k^- = \sum_{K=1}^{T} MIN(\Delta lnFI_k, 0) \end{matrix}$$

Now, the asymmetric long-run and short-run coefficient assessment as follows:

$$\Delta CE_t = \partial U_{t-1} + (\beta^+ GI^+_{1,t-1} + \beta^- GI^-_{1,t-1}) + (\gamma^+ FP^+_{1,t-1} + \gamma^- FP^-_{1,t-1}) + (\pi^+ ET^+_{1,t} + \pi^- ET^-_{1,t}) + \delta X^*_{1,t-1} + \sum_{j=1}^{m-1} \lambda_j \Delta CE_{t-j_0} + \sum_{j=1}^{n-1} (\pi^+ \Delta GI^+_{1,t-1} + \pi^- \Delta GI^-_{1,t-1}) + \sum_{j=0}^{m-1} (\beta^+ \Delta FP^+_{1,t-1} + \beta^- \Delta FP^-_{1,t-1}) + \sum_{j=0}^{m-1} (\beta^+ \Delta ET^+_{1,t-1} + \beta^- \Delta ET^-_{1,t-1}) + \sum_{j=0}^{m-1} \mu \Delta X^*_{1,t-1} + \varepsilon_t$$

It is imperative to employ a conventional Wald test to detect asymmetry in both the long and short run. This test will evaluate the null hypothesis of symmetry. Confirming an asymmetric relationship, whether in the long run or short run, relies solely on the insignificance of the test statistics. Furthermore, the empirical model's asymmetric long-run cointegration will be assessed using F-bound testing, Joint Primality test, and tBDM test. The confirmation of asymmetric cointegration occurs when the test statistics surpass the critical value.

6. Estimation and Interpretation

The study implemented the Perron and ADF unit root test in documenting the stationary proprieties of the CE, GI, FP, ET, OP, and NRR measures and their results in Table 2, according to the associated *p*-value of each test statistic, which is found statistically significant at a 1% level after the first difference operation, indicating the variables' order of integration after the first difference in all cases.

Table 2. Results of Perron and Vogelsang and ADF unit root test.

Variables	Perron and Vogelsang			ADF Test	
Level	**Test Statistics**	**Significance**	**D-SB**	**Test Statistics**	**Significance**
			At level		
REC	−1.8069		2017	−1.0568	
GI	−2.6665		2005	−2.0403	
FP	−1.6413		2011	−0.4523	
ET	−0.9761		2009	−1.0711	
OP	−1.4142		2010	−2.1594	
NRR	−1.0498		2011	−2.8125	
			First difference		
REC	−6.9541	***	2000	−4.4116	***
GI	−8.6554	***	2005	−6.5487	**
FP	−10.3722	***	2003	−7.3499	***
ET	−9.4468	***	2000	−5.3761	***
OP	−6.729	***	1994	−8.9776	***
NRR	−8.0452	***	2004	−4.4941	***

Note: the superscript of *** and ** explained the level of significance at a 1% and 5% level.

Documenting the long-run association between CE, GI, FP, ET, OP and NRR, the study executed the cointegration test following [75]. Table 3 reports the results of Bayer–Hancked cointegration. The study unveiled a long-run association in the empirical nexus.

The long-run assessment was extended through the execution of a standard Wald test under the symmetric and asymmetric framework. The results are available in Table 4. Referring to the test statistic derived from standard Wald test statistics, that is, $F_{overall}$, t_{DV}, and F_{IDV}, it is apparent that all the test statistics are statistically significant at 1%; alternatively, the test statistics have been found higher that the critical value in any circumstance.

Table 3. Bayer–Hancked and Maki cointegration test.

	1	**2**	**3**	**4**	**5**
Panel–A: Bayer–Hancked cointegration					
EG-JOH	14.891	10.965	11.339	10.951	10.632
Critical value 5%	11.229	10.895	10.637	10.576	10.419
EG-JOH-BO-BDM	31.369	24.577	22.167	20.969	20.886
Critical value 5%	21.931	21.106	20.486	20.143	19.888
Panel–B: Maki cointegration					
Number of Breaks Points	Test Statistics	(Critical Values)		Break Points	
Tb < 5					
0	−7.2462	−6.306		2015, 2020, 1994, 2004, 2018	
1	−8.4724	−6.494		2021, 2000, 1999, 2005, 1996	
2	−8.0196	−8.869		2004, 2008, 2018, 2013, 1998	
3	−7.457	−9.482		2003, 2010, 2006, 2011, 2005	

Table 4. Long-run cointegration assessment: symmetric and asymmetric framework.

Long-Run Cointegration	$F_{overall}$	t_{DV}	F_{IDV}
ARDL	10.615 ***	−5.704 ***	8.011 ***
NARDL	7.145 ***	−5.949 ***	10.006 ***

Note: the *** denotes the significance level at a 1% level.

Long-Run and Short-Run Coefficients: Linear and Nonlinear Estimation

Table 5 displayed the results of symmetric and asymmetric estimation. According to the research, the coefficient of GI on REC is positive and statistically significant at the 1% level in the long run (0.1473) and short run (0.0338), indicating a strong and substantial association between GI and REC. The long-run shock coefficient of 0.1924 suggests that a continuous increase in GI will lead to a corresponding rise of 0.1924 in REC over an extended period. The present research uncovers a durable and statistically significant correlation between investments in environmentally friendly initiatives, GI, and RE sources' utilization. GIs contribute to the development and implementation of RE technology. The positive long-term effects of these investments demonstrate the effectiveness of policies and programs promoting the adoption of clean energy. The coefficient of the long-run negative shock, which is 0.1455, suggests that a sustained decrease in GI will lead to a corresponding decline of 0.1455 in REC over an extended period. The findings of this research indicate that a decrease in GI could potentially yield adverse consequences for REC, consequently hindering the growth and adoption of clean energy technology. It underscores the importance of maintaining sustained support for GIs to accomplish long-term energy goals. The coefficient of the positive shock in the short run, which is 0.0702, suggests that a temporary increase in GI will lead to a corresponding increase of 0.0702 in REC in the immediate term. The short-term effect implies that a positive shock to GI could immediately impact adopting RE technology. Short-term regulations and economic incentives can expedite the adoption of RE sources, thereby addressing energy demands and concurrently attaining environmental goals. The short-term negative shock value of 0.0244 suggests that a temporary decline in GI will lead to a corresponding decline of 0.0244 in REC. This finding is consistent with past research [21,38,50,77,78].

Table 5. Long-run and short-run coefficients: symmetric and asymmetric estimation.

	Symmetric Estimation				Asymmetric Estimation		
	Coefficient	***t*-Stat**	**Std. Error**		**Coefficient**	***t*-Stat**	**Std. Error**
			Panel–A: Long-run coefficients				
GI	0.1473	0.0039	37.7692	GI+	0.1924	0.0037	52.021
FP	0.1096	0.0101	10.8514	GI−	0.1455	0.0057	25.5263
ET	0.1775	0.0119	14.9159	FP+	0.1624	0.0031	52.387
OP	−0.0637	0.0068	−9.3676	FP−	0.1315	0.0082	16.0365
NRR	−0.1051	0.0074	−14.2027	ET+	0.1739	0.0078	22.2948
				ET−	0.1234	0.0042	29.3809
				NRR	−0.1361	0.0075	−18.1466
				OP	0.0964	0.0105	9.1809
C	0.103468	0.005717	18.09834	C	0.1176	0.0036	32.6666
W_{GI}					5.281		
W_{FP}					8.134		
W_{ET}					5.336		
short-run							
GI	0.0338	0.0027	12.5185	GI+	0.0702	0.0042	16.7142
FP	0.0715	0.0075	9.5333	GI−	0.0244	0.008	3.05
ET	0.0681	0.0094	7.2446	FP+	0.0361	0.0094	3.8404
OP	0.0299	0.0099	3.0202	FP−	0.0472	0.0063	7.492
NNR	0.0085	0.003	2.8333	ET+	0.0567	0.0086	6.593
				ET−	0.0652	0.0099	6.5858
				NRR	0.023	0.0041	5.6097
				OP	0.0334	0.0047	7.1063
ECT	−0.7988	0.1985	−4.02418136		−0.800539	0.0886	−9.0354
W_{GI}					11.371		
W_{FP}					5.118		
W_{ET}					3.159		

A 10% augmentation in fiscal policy measures, encompassing tax breaks and subsidies specifically targeted towards RE projects, is associated with a proportional increase of $0.1096 \times 10\% = 1.096\%$ in the utilization of RE sources. Based on the existing body of research, it can be argued that fiscal policies that demonstrate support for investments in RE have the potential to create a conducive environment [19,21,49,79,80]. These policies have the potential to foster increased private sector involvement and facilitate the adoption of RE sources by alleviating the financial burdens and risks associated with transitioning to clean energy. The positive coefficient in the context of fiscal policy implies that meticulously crafted fiscal policies, which effectively promote the adoption of RE sources, have the potential to yield a favorable outcome in terms of enhancing REC. Empirical research has established that implementing fiscal measures, such as tax incentives, grants, and subsidies, can effectively serve as catalysts for stimulating investments in sustainable energy and subsequently augmenting its overall consumption [13]. Fiscal policies can potentially be pivotal in expediting the transition towards RE sources through financial assistance and reducing cost impediments [81].

The long-run and short-run coefficients of ET were positive and statistically significant at a 1% level, suggesting that environmental protection through excess tax will result in the augmentation and inclusion of RE source consultation in the economy. Precisely, a 10% change in ET will amplify the clean energy demand by 1.775% in the long run and 0.681% in the short run. Furthermore, the study finding of asymmetric coefficients of environmental taxon RE % consumption has revealed positive connections in the long run (a coefficient of positive shock is 0.1739 and the negative shock is 0.1234) and short run (the coefficient of positive shock is 0.0567 and the negative shock is 0.0652). The study's findings suggest that both long-term and short-term outcomes demonstrate that environmental taxes exert a positive and asymmetric influence on REC. Despite fluctuations or temporary reductions, environmental tax measures effectively encourage the adoption of RE, bolster sustainable energy practices, and make significant contributions to environmental conservation [12,59,82,83].

Study findings explained a 10% rise in oil prices and a corresponding alteration in REC, resulting in a decrease of −1.775%, demonstrating that elevated oil prices can diminish the impetus to adopt and utilize RE sources. The cost advantage associated with traditional energy sources may lead consumers and industries to exhibit reduced inclination towards investing in environmentally friendly alternatives following elevated fossil fuel prices [1,4,13,49,84–87]. On the contrary, the dwindle in oil prices can incentivize a more pronounced shift toward utilizing RE sources [33,64,88–91].

The consumption of RE exhibits a negative correlation with the increase in natural resource rent, as evidenced by a change of $-0.1051 \times 10\% = -1.051\%$ in REC for every 10% increment in natural resource rent. Based on extant scholarly literature, for example, [14,40,56,90,92,93], it has been observed that countries heavily dependent on exploiting natural resources may exhibit a diminished propensity to allocate resources towards the development and implementation of RE sources. The phenomenon above is commonly denoted as the "resource curse." The potential decline in motivation to conduct research and adopt clean energy technology may ensue as natural resource rents increase, ultimately reducing RE source utilization. Natural resource rent implies an inverse correlation between the abundance of natural resources and the utilization of RE. This discovery aligns with the widely accepted "resource curse" theory, which suggests that economies heavily reliant on natural resource exports may exhibit less inclination to invest in RE, primarily due to the perception of abundant traditional energy sources. Nevertheless, the interplay between government policies and acknowledging the limited availability of fossil fuel resources can potentially temper this correlation.

Table 6, consisting of Panel–A for symmetric estimation and Panel–B for asymmetric estimation, displays the results of the residual diagnosed test, and all the *p*-values of the associated test statistics were statistically insignificant. It suggests that the residuals are independent and not correlated, validating the regression findings, residual heteroscedasticity is absent, the residuals do not have conditional heteroscedasticity, the Ramsey RESET suggests that the independent factors explain the dependent variable's fluctuation and that no new variables are needed to improve the model's fit. The Jarque–Bera test confirms the residuals are normally distributed.

Table 6. Result of residual diagnostic test: symmetric and asymmetric assessment.

	***p*-Value**	**Results**
Panel–A: for symmetric framework		
Breusch–Godfrey LM test	0.682	Absence of serial correlation
Breusch–Pagan–Godfrey test	0.637	No issue dealing with heteroskadacity
ARCH Test	0.859	No issue dealing with heteroskadacity
Ramsey RESET Test	0.684	Model construction with efficiency
Jarque–Bera test	0.516	Residuals are normally distributed

Table 6. *Cont.*

	p-Value	Results
Panel–B: For asymmetric framework		
Breusch–Godfrey LM test	0.508	Absence of serial correlation
Breusch–Pagan–Godfrey test	0.58	No issue dealing with heteroskadacity
ARCH Test	0.883	No issue dealing with heteroskadacity
Ramsey RESET Test	0.54	Model construction with efficiency
Jarque–Bera test	0.626	Residuals are normally distributed

7. Discussion

The coefficient of GI on REC is positively and statistically significantly related at the 1% level in both the long run (0.1473) and short run (0.0338), implying a strong and meaningful connection between GI and REC. This outcome indicates that an increase in GI is connected to increased utilization of RE sources. In the long run, the coefficient of 0.1473 reveals that it will grow by 0.1473 units for every unit increase in GI. This positive coefficient signifies that as we invest in RE projects, like wind farms and solar installations, the utilization of RE sources grows sustainably as time goes on. This discovery aligns with the belief that investing in green initiatives is vital for fostering the enduring embrace and utilization of RE technologies. In the same way, the coefficient of 0.0338 reveals that GI brings about an immediate effect on the utilization of RE. Shortly, REC will rise by 0.0338 units for each unit of GI that is augmented, which signifies that GI endeavors have an immediate impact on advancing the utilization of RE sources, perhaps by establishing fresh undertakings or enlarging prevailing infrastructure. This outcome is in line with previous investigations in the field. Many studies have shown the good effects of investing in green initiatives on using RE [29,38,48,50,64,78,85,88].

The study reveals that the coefficient of fiscal policy on REC exhibits a positive and statistically significant association at the 1% level, both in the long run (with a coefficient of 0.1096) and short run (with a coefficient of 0.0715). This finding suggests a robust and noteworthy relationship between fiscal policy and the consumption of RE. The coefficient of 0.1096 signifies a corresponding increase of 0.1096 units in REC in the long term for every unit rise in fiscal policy measures. A positive coefficient in this analysis indicates that fiscal measures aimed at promoting RE, such as tax incentives, subsidies, or grants, have a lasting impact on the expansion of RE sources. Similarly, a correlation coefficient of 0.0715 suggests that fiscal policy exerts an immediate impact on the utilization of RE. In the short term, it has been observed that there is a corresponding increase of 0.0715 units in REC for each unit increase in fiscal policy measures. This statement suggests that economic measures can potentially exert an immediate influence on promoting the adoption and utilization of RE technology. The finding mentioned above aligns with prior research and theoretical conjectures. Fiscal policies are crucial in incentivizing investment and facilitating the adoption of RE sources. Tax breaks and subsidies can reduce RE projects' costs, enhancing their attractiveness to consumers, companies, and investors. The results of this study exhibit similarities with the findings of [75,82,85]. Tax incentives, grants, subsidies, and other fiscal measures have the potential to alleviate the financial strain faced by developers and investors in the RE sector. Consequently, these measures can enhance clean energy initiatives' financial allure and economic feasibility. Consequently, there is a subsequent rise in the utilization of sustainable energy solutions, exemplified by the adoption of photovoltaic solar panels, wind turbines, and bioenergy endeavors. Fiscal policies exert a significant influence on the adoption of RE technologies, thereby promoting their utilization among both consumers and enterprises. Tax credits and rebates aimed at incentivizing the installation of solar panels, acquisition of electric vehicles, and investment in energy-efficient appliances, among other examples, have the potential to effectively promote the widespread adoption of RE sources and energy-saving technologies. The adoption rates of RE solutions can be enhanced by implementing fiscal incentives, which serve to decrease the initial costs incurred by end-users. Governments can employ fiscal policy to bolster research and development (R&D) endeavors within the RE sector. The financing of research and development (R&D) endeavors can yield significant benefits, including but not limited to technological advancements, cost reductions, and improved performance within RE technologies.

The adoption of RE sources is being accelerated due to the advancements in research, which enhances their competitiveness compared to conventional fossil fuels. Fiscal policies aimed at promoting the consumption of RE sources have the potential to enhance energy security and foster sustainability significantly. Countries can enhance their resilience to price volatility and supply disruptions in the global energy markets by strategically implementing energy portfolio diversification and reducing their dependence on imported fossil fuels. Furthermore, it is worth noting that RE sources have the distinct advantage of emitting significantly fewer greenhouse gases. This characteristic is pivotal in bolstering endeavors to mitigate the adverse effects of climate change and attaining sustainability goals.

According to the research results, environmental taxes (ET) have a favorable and statistically significant influence on RE use in both the long and short term, suggesting that employing extra tax resources for environmental protection measures may enhance the adoption and incorporation of RE sources into the economy. A 10% rise in ET is related to a 1.775% increase in long-run clean energy demand and a 0.681% increase in short-run clean energy demand. ET coefficients that are positive and statistically significant in both the long-run and short-run illustrate the efficacy of employing ET revenues to stimulate the use of RE. Governments may promote sustainable energy consumption habits and decrease dependency on fossil fuels by adopting clean energy technology via fiscal measures, resulting in environmental benefits and enhanced energy security. Furthermore, the research results show unequal coefficients of ET on RE usage, implying that the long-run and short-run effects of positive and negative shocks to ETs on clean energy usage vary. The research showed that positive shocks to ETs had a greater beneficial effect on RE usage than negative shocks. The coefficient of positive shock (0.1739) indicates that a positive change in ET increases REC more than the coefficient of negative shock (0.1234), which indicates that a negative change in ET has a smaller effect on clean energy consumption. These data imply that improving ET measures may lead to more considerable and long-term gains in REC, while decreasing ET measures may have a comparatively lesser long-term influence on clean energy adoption. The research also discovered the uneven impacts of environmental taxes on RE usage in the near term. The positive shock coefficient (0.0567) indicates that a positive change in ET leads to a moderate increase in clean energy consumption. In contrast, the negative shock coefficient (0.0652) indicates that a negative change in ET has a slightly larger effect on REC in the short term. This conclusion shows that, in the near term, lowering ETs may have a somewhat greater influence on clean energy use than raising environmental taxes.

The potential of an ET lies in its ability to stimulate and promote the adoption of clean and sustainable energy sources, which is where its beneficial influence on RE usage truly resides. Environmental taxes are a form of fiscal policy specifically addressing environmental damage's origins, including pollution and greenhouse gas emissions [54,83]. The funds derived from the ET can be allocated towards a range of environmental safeguards and sustainable energy initiatives. An explanation of how the beneficial effects are produced is given in the following section. The utilization of detrimental energy sources, such as fossil fuels, incurs additional costs in the form of environmental fees, which implies that the cost of energy derived from conventional sources will experience a relative increase compared to that generated from renewable sources, thereby enhancing the attractiveness of the latter option for both households and companies [56,95]. Environmental tariffs on energy can incentivize businesses and consumers to transition towards more energy-efficient practices. Energy efficiency measures promote the utilization of RE sources, which are often more economically advantageous in the long term than conventional fossil fuels, by effectively reducing overall energy consumption. Environmental fees can finance additional research and advancement in RE sources [11,33,96]. The implementation of environmental levies for providers of RE has the potential to enhance market conditions. The expansion of the clean energy sector not only generates employment opportunities but also stimulates economic growth. The positive impact of an ET on the utilization of RE is a comprehensive approach that addresses environmental concerns, promotes sustainable energy practices, and supports global efforts to combat climate change. Environmental taxes are crucial in facilitating society's transition towards a more sustainable and environmentally friendly future, primarily due to their ability to offer financial incentives for adopting clean energy sources and promoting RE initiatives [97,98].

The study's results illustrate a notable inverse correlation between the utilization of RE and the increase in rental expenses linked to natural resources. The correlation of −0.1051 suggests an inverse relationship between natural resource rent and RE usage. Specifically, a 10% increase in natural resource rent is associated with a decrease of −1.051% in RE usage. The discovery mentioned above is consistent with previous studies found in the academic literature. In these studies, researchers [14,40,56,99–101] have thoroughly investigated the phenomenon known as the "resource curse." The hypothesis posits that nations heavily dependent on the extraction and utilization of natural resources may encounter challenges in diversifying their economies and allocating resources toward promoting and adopting RE alternatives [102–105]. The abundant availability of traditional energy sources, made easier by natural resource rents, could reduce the incentive to direct investments toward RE technology [106–109]. As a result, countries with significant income derived from natural resources may exhibit a diminished propensity to adopt and employ RE sources [110–114]. The finding holds significant importance for policymakers and governments in resource-rich economies. While the utilization of natural resources can yield significant economic benefits, it is not without its drawbacks. These include overreliance on fossil fuels and potential adverse environmental consequences. Given the well-documented phenomenon commonly referred to as the "resource curse", it becomes imperative for policymakers to consider implementing strategic measures that effectively promote the allocation of resources towards RE sources while simultaneously facilitating the widespread adoption of clean energy technology. Government policies play a crucial role in effectively addressing the negative correlation between natural resource rents and the utilization of RE within this specific context [115].

8. Conclusions and Policy Suggestions

Conclusions

This research endeavor has sought to elucidate the complex interplay between different variables that impact the adoption of clean energy, with the ultimate goal of fostering sustainable development. Given the profound comprehension of the urgent global challenges presented by climate change and environmental degradation, there exists an unprecedented drive to shift toward cleaner and more sustainable energy sources. The research is motivated by diminishing fossil fuel reserves, increasing greenhouse gas emissions, and rising recognition of the importance of environmentally sustainable practices. Driven by the pressing nature of the current global energy and environmental context, our research endeavors to comprehensively analyze the intricate relationships between green investment, fiscal policy, environmental tax, energy prices, natural resource rent, and the utilization of clean energy sources. By employing a combination of linear and nonlinear methodologies, our study endeavors to offer a holistic understanding of the potential impacts of these variables on the utilization of clean energy, encompassing both the long-term and short-term perspectives. Using empirical analysis, our research has effectively bolstered the proposed relationships, fortifying our findings' overall strength and validity.

The findings of our study elucidate the noteworthy and affirmative association between green investment, fiscal policy, environmental tax, and the utilization of clean energy. Positive and statistically significant coefficients emphasize the effectiveness of policies and initiatives designed to encourage the adoption of renewable energy. Our research highlights the significant impact of green investment in fostering the expansion of clean energy adoption. The study highlights the long-lasting and immediate effects of fiscal policies on the proliferation of renewable energy sources, underscoring the crucial role of government assistance in this pursuit. Moreover, it is worth noting that the commendable impact of environmental taxes on the promotion of clean energy consumption highlights their significant potential as drivers for preserving the environment and the widespread adoption of sustainable energy practices.

Furthermore, our research findings provide additional insight into the negative relationship observed between oil prices, natural resource rent, and clean energy consumption. The dynamics above highlight the potential obstacles that economies reliant on natural resource exports may encounter when shifting toward clean energy sources. The findings presented in this study align with previous research in the field, thereby reinforcing the significance of adopting a nuanced approach to policy-making that duly considers the intricate nature of national economic systems.

Based on the study findings, we have developed the following policy suggestions for future developments in clean energy inclusion:

1. Governments must adopt and enforce policies that promote and facilitate the adoption of GI in various RE sources, including but not limited to hydropower, solar, and wind energy. Tax credits, grants, or subsidies can be utilized as incentives to promote RE technology investments by corporations and individuals.
2. Governments must formulate budgetary strategies that prioritize environmental protection and sustainable development, which may entail reallocating funds towards environmentally favorable programs, reducing subsidies for fossil fuels, and augmenting funding for the research and advancement of RE technology.
3. Environmental tariffs can potentially be highly effective in discouraging harmful activities and generating funds for initiatives focused on environmental conservation. It is recommended that governments impose taxes on carbon emissions, industrial pollution, and the exploitation of non-renewable resources to discourage their utilization and generate financial resources for investments in sustainable energy alternatives.
4. Governments must strive to implement fair pricing structures for energy consumption, which duly account for the genuine costs of different energy production sources. When pricing models consider environmental externalities, consumers tend to be more inclined toward making decisions that promote the transition to cleaner forms of energy.
5. It is imperative to prioritize the implementation of sustainable natural resource management. Governments must formulate comprehensive strategies aimed at effectively and sustainably managing natural resources, which can be achieved by implementing stringent regulations that prevent the excessive exploitation of vital resources, including forests and waterways, through the promotion of ethical mining practices, the safeguarding of wildlife habitats, and the enforcement of more stringent waste disposal regulations.

The shortcomings of this study are as follows: first, the study's primary emphasis on Cambodia may constrain the extent to which the findings can be extrapolated to other geographic contexts or countries exhibiting distinct economic and environmental attributes. The observed relationships may be subject to varying influences in different regions due to the distinctive socio-economic landscape of Cambodia. Second, the study combines linear and nonlinear frameworks to comprehensively examine potential effects. However, it is crucial to acknowledge that even with this approach, no model can entirely encompass the intricate nature of real-world interactions. The accuracy of the results may be influenced by the simplifications and assumptions employed during the modeling process. Third, the study is centered around a distinct set of variables about green investment, fiscal policy, environmental tax, energy price, and natural resource rent. In the analysis, omitting other potentially relevant variables, such as technological innovation rates or social acceptance of clean energy, may be attributed to the constraints imposed by data limitations.

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