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Research Article

The Nexus of GDP and Sustainability: Indonesia's Renewable Energy, Natural Resource Rent, and Economic Growth

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Abstract.
This study aims to explore and test the relationship between GDP and renewable electricity output, renewable energy consumption, and total natural resource rent in Indonesia. It uses Vector Error Correction Model (VECM) analysis on World Bank data from 1995 to 2019, with a primary focus on Indonesia, to investigate the complex relationship between GDP and key sustainability metrics. This analysis highlights how Indonesia's economic growth is influenced by changes in the consumption of renewable energy, utilization of natural resources, and its impact on the environment over a span of 25 years. Ultimately, this research provides important insights for policy makers and researchers on Indonesia's evolving sustainability landscape, thereby facilitating the development of strategies that balance economic growth and prosperity, and environmental conservation.

Keywords: GDP, renewable electricity output, renewable energy consumption, total natural resource rent

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1. Background

In the contemporary global landscape, the intricate interplay between economic growth and sustainable energy practices has gained substantial attention as societies grapple with the challenges of environmental degradation and the imperative for a greener future. The relationship between these two seemingly unrelated forces grows more pronounced as governments strive to establish a harmonious balance between economic development and ecological preservation. The pursuit of renewable energy uptake and consumption is increasingly entwined with the quest for sustainable economic growth, usually gauged by GDP. This confluence of objectives arises from the realization that traditional models of growth predicated solely on resource-intensive industries are fraught with ecological consequences that undermine the very foundation upon which economies are built. Sustainable energy practices, based on the diversification of energy sources and the move away from fossil fuels, mark a paradigm change with effects that go beyond financial rewards [1]. It reflects a broader understanding that human welfare is inextricably linked to the health of the environment, compelling governments, businesses, and civil society to work together to reimagine development trajectories that avoid the traditional trade-offs between development and environmental protection. The implications of this intricate interplay ripple across academic discourse, policy frameworks, and strategic investments, ushering in an era where the variables of GDP, renewable electricity output, renewable energy consumption, and total natural resource rents converge to chart a course towards a more sustainable and resilient future [2].

The ever-evolving landscape of global economics and environmental sustainability, the variables of GDP, renewable electricity output, renewable energy consumption, and total natural resource rents have gained substantial significance. In an era marked by heightened awareness of climate change, resource scarcity, and the transformative potential of technological innovations, these variables serve as critical touchstones that illuminate the intricate relationship between economic prosperity and planetary well-being [3]. The backdrop of economic growth, as measured by GDP, sets the stage for a multifaceted dialogue that navigates the complexities of development in an era of ecological constraints. While economic expansion has historically been synonymous with increased resource consumption and emissions, a pivotal paradigm shift has transpired, wherein the imperative for sustainability has ushered in a new era of economic growth defined by resource efficiency, circular economies, and clean technologies. The measures of renewable power output and renewable energy consumption, which capture a country's commitment to lowering its carbon footprint, boosting energy security, and encouraging innovation in the field of green technology, serve as an illustration of this trend [4]. The culmination of these efforts is encapsulated within the construct of total natural resource rents, a metric that symbolizes a nation's aptitude in responsibly managing its resource endowment. As the discourse on sustainable development gains momentum, these variables intersect to shape policy decisions, investment priorities, and societal aspirations, steering nations towards a trajectory that holds promise not only for economic prosperity but also for a more resilient and harmonious coexistence with the environment. This dynamic interplay underscores the profound interconnectedness between economic advancement, renewable energy, and resource stewardship, redefining the contours of progress in the pursuit of a more sustainable and equitable global future [5].

In the captivating tapestry of Indonesia's evolving socio-economic landscape, the dynamic interplay of GDP growth, adoption of renewable energy, and the management of its abundant natural resources has become a focal point of both domestic policy and international scrutiny. As Indonesia strides forward as a burgeoning economic powerhouse in Southeast Asia, its GDP has consistently surged, driven in part by the exploitation of its rich natural resource reserves. Yet, this economic growth has arrived hand-in-hand with ecological concerns, as the nation grapples with the delicate balancing act of sustaining its thriving economy while safeguarding its unparalleled biodiversity and ecosystems [6]. Amidst these challenges, Indonesia's commitment to embracing renewable energy sources emerges as a beacon of hope for sustainable development. The country's sprawling archipelago offers an array of renewable energy possibilities, from geothermal treasures beneath its surface to the tropical sun that graces its islands, and the rivers that cascade through its landscapes. By harnessing these resources, Indonesia is not only charting a course towards reduced carbon emissions and enhanced energy security, but also creating a blueprint for the harmonization of economic aspirations with environmental stewardship. This shift is not confined to electricity generation alone; it extends to reimagining the entire energy consumption paradigm [7]. Encouraging a higher percentage of renewable energy consumption within Indonesia's energy mix signifies a commitment to altering consumption patterns across industries, transportation, and households. As the nation seeks to reshape its energy landscape, it faces the challenge of balancing the need for rapid development with a sustainable and inclusive approach that benefits all citizens. Additionally, Indonesia's journey is further colored by the prudent management of its natural resource rents, a critical economic factor that must be harnessed with foresight. The nation's policymakers find themselves at a crossroads, navigating the complex terrain of optimizing resource extraction without compromising the long-term health of its ecosystems and the well-being of its people. As Indonesia stands on the precipice of opportunity and responsibility, the prudent orchestration of these interconnected variables will not only define its national trajectory but also resonate globally as a testament to the transformative potential of sustainable development. This study aims to explore and test the relationship between GDP and Renewable Electricity Output, Renewable Energy Consumption, and Total Natural Resource Rents in Indonesia.

2. Literature Review

The value of all products and services generated inside a nation's borders is captured by the GDP, a key indicator in economic research. It serves as a touchstone for evaluating the economic progress and overall well-being of a nation, representing a fundamental metric by which policymakers and economists assess a country's economic health. The importance of GDP rests in its capacity to offer a complete picture of a country's economic activity, taking into account not just the economy's size but also its growth trajectory and wealth distribution. In this study, GDP forms the bedrock on which the intricate connections between economic development and the trajectory towards sustainable energy practices are explored. GDP stands as a quintessential indicator of a nation's economic health, reflecting the total monetary value of all goods and services produced within its borders [8]. It serves as a yardstick for evaluating economic growth, development, and standard of living. Historically, countries with higher GDP figures have enjoyed greater access to resources, improved infrastructure, and enhanced living standards, underscoring the importance of economic prosperity in enhancing the quality of life [9]. Nevertheless, the correlation between GDP and other variables is complex; while economic growth often leads to increased resource consumption, it can also facilitate investments in renewable energy and sustainable practices, highlighting the dual role GDP plays in shaping environmental outcomes. Balancing economic expansion with environmental stewardship remains a central challenge for policymakers and researchers alike, as they seek to navigate the intricate interplay between GDP growth and sustainability goals.

Renewable electricity output assumes a pivotal role within this research, acting as a vital gauge of a country's commitment to curbing its carbon footprint and transitioning towards cleaner energy sources. This variable represents a fundamental aspect of the energy landscape, quantifying the percentage of a nation's electricity generation derived from renewable sources such as wind, solar, hydro, and geothermal power [10]. Its significance lies in its capacity to serve as a powerful indicator of environmental responsibility and economic progress. A higher percentage of renewable electricity output indicates a proactive stride toward embracing environmentally responsible energy alternatives while fostering economic advancement. It showcases a nation's dedication to reducing greenhouse gas emissions, mitigating the impacts of climate change, and contributing to the global shift towards sustainable energy systems [11]. The global shift towards renewable energy sources has gained momentum as concerns about climate change and finite fossil fuel resources intensify. The amount of electricity generated from renewable sources, represented as a percentage of all electricity produced, indicates how much a country depends on renewable energy sources like solar, wind, hydroelectricity, and geothermal energy [12]. Beyond its environmental implications, this metric underscores the strategic benefits of renewable energy adoption. Countries that prioritize renewable energy development seek to reduce carbon emissions, enhance energy security, and create jobs within the growing green technology sector. A higher percentage of renewable electricity output not only signals a commitment to sustainable energy generation but also signifies a reduced reliance on fossil fuels, thereby enhancing a nation's energy resilience and environmental stewardship. In this context, the study delves into the intricate relationship between renewable electricity output and broader sustainability goals, shedding light on the transformative potential of clean energy adoption for both nations and the planet [13].

When analysing a country's energy structure, the consumption of renewable energy serves as a vantage point to show the proportion of renewable energy sources in the total energy consumption matrix. This indicator serves as a crucial measure of a nation's progress in weaning itself off fossil fuels and towards sustainable alternatives. A larger percentage demonstrates a dedication to lowering emissions of carbon and mitigating the harmful effects of climate change, reflecting an honest effort to balance economic progress with ecological sustainability [14]. It serves as an illuminating indicator, shedding light on a nation's energy transition journey and its adherence to global sustainability objectives. The consumption of renewable energy as a share of total final energy consumption offers detailed insights into an economy's entire energy balance and its transition to sustainability [14]. This metric extends beyond the confines of electricity generation to encompass the use of renewables in transportation, heating, and industrial processes, demonstrating the versatility of sustainable energy sources. Diversifying the energy portfolio with renewable sources not only mitigates the environmental impact associated with conventional energy but also reduces dependency on volatile global energy markets, enhancing a nation's energy security [15]. Moreover, it fosters innovation in energy technologies, propelling the development of cleaner and more efficient energy solutions. Countries that put a high priority on growing their use of renewable energy make major contributions to the global effort to slow down global warming, improve sustainability, and ensure future generations will have access to sustainable energy.

Total natural resources rents signifies the economic value harnessed from a country's natural resources, expressed as a fraction of its Gross Domestic Product (GDP). This multifaceted variable stands as a critical lens through which to examine the intricate interplay between economic development and environmental preservation. It underscores the paramount significance of judicious resource management in achieving economic progress while preserving the integrity of the environment [16]. In essence, this metric crystallizes the inherent tension between harnessing natural wealth for human well-being and safeguarding the planet's ecological equilibrium. Natural resource rents, encapsulated by this metric, encompass the income generated from the extraction and exploitation minerals, oil, and gas. When expressed as a percentage of GDP, this metric provides valuable insights into the extent to which a nation's economic growth relies on finite resources. The significance of high resource rents cannot be overstated, as they can indeed fuel economic growth in the short term, providing governments with substantial revenues for development projects and social programs. However, the flip side of this economic boon lies in the complex challenges it presents [17]. These challenges include resource depletion, which can have severe long-term consequences, price volatility in global commodity markets that can disrupt economic stability, and economic vulnerability stemming from over-dependence on resource exports. Consequently, the wise management of resource rents becomes imperative for resource-rich nations, who must navigate the delicate balance between harnessing natural resources for immediate economic development and ensuring their sustainable management for the long-term prosperity of their economies. The equilibrium between economic prosperity and responsible resource utilization emerges as a central concern when contemplating the implications of Total Natural Resources Rents (% of GDP). It highlights the pressing need for comprehensive resource governance frameworks that incorporate sustainability principles, environmental protection, and equitable distribution of resource wealth. Striking this balance is not only essential for the economic viability of resource-dependent nations but also pivotal in addressing global concerns related to climate change, biodiversity loss, and the depletion of vital natural assets. This metric also emphasises the significance of responsible resource management in the global context and acts as a potent reminder that sustainable development is not only a desire but an imperative for the well-being of current and future generations [18].

The intricate interplay of these variables forms the foundation of discussions on sustainable development, environmental conservation, and economic resilience. As global challenges like climate change and resource scarcity intensify, finding innovative solutions that consider the synergies and trade-offs among these variables is imperative for a more secure, equitable, and sustainable future. The intricate relationship between GDP and sustainability metrics, including Renewable Electricity Output, Renewable Energy Consumption, and Total Natural Resources Rents, underscores the multifaceted nature of modern economic development. Using renewable energy A nation's commitment to a transition to cleaner energy sources can be measured by output as a share of total power generation. It expresses the understanding that environmental sustainability and economic growth are not always antagonistic but rather can work in tandem. The rise of renewable energy technologies not only contributes to reduced carbon emissions but also fosters innovation, job creation, and energy security, thereby positively influencing GDP through various channels [19]. Similarly, Renewable Energy Consumption offers a broader perspective by encompassing the utilization of renewable energy in diverse sectors. This metric not only signifies the diversification of energy sources but also represents a strategic shift towards sustainable energy practices. Here, the relationship with GDP becomes more intricate as economic growth can be either a driver of increased energy consumption or a catalyst for more efficient energy use and the adoption of renewable energy solutions. In the latter scenario, GDP growth becomes intertwined with sustainability, reflecting the transformative potential of green economies [20]. On the flip side, Total Natural Resources Rents introduces a different dimension to the relationship. It sheds light on the economic value derived from natural resources, particularly non-renewable ones like minerals and fossil fuels. While high resource rents can temporarily boost GDP, they also pose sustainability challenges, including resource depletion and economic vulnerability. This indicator emphasises the need for prudent resource management to guarantee the long-term prosperity of resource-rich countries and is in line with the larger global movement for sustainable development, which recognises the interaction between economic growth and environmental stewardship [21].

The relationship between GDP and sustainability metrics like Renewable Electricity Output, Renewable Energy Consumption, and Total Natural Resources Rents is a complex interplay that presents both pros and cons. On the positive side, when GDP is positively correlated impacted with Renewable Electricity Output and Consumption of Renewable Energy, it signifies a transition towards cleaner and more sustainable energy sources. This can lead to reduced carbon emissions, improved air quality, and greater energy security. Moreover, investments in renewable energy technologies can stimulate economic growth through job creation, innovation, and the development of a burgeoning green technology sector [22]. It also reflects a commitment to aligning economic progress with environmental responsibility, which is increasingly important in the face of climate change and environmental degradation. However, there are potential downsides to this relationship as well. One of the challenges is the initial high capital costs associated with renewable energy infrastructure, which can temporarily strain GDP growth in the short term. Additionally, the transition from traditional energy sources to renewables may necessitate adjustments in various industries, potentially leading to economic disruptions and job displacement in sectors reliant on fossil fuels [23]. Furthermore, the integration of renewables into the energy grid can pose technical challenges, including intermittency and grid stability concerns, which may require significant investments in grid infrastructure.

Regarding Total Natural Resources Rents, a high correlation with GDP can boost a nation's economic growth through resource extraction and export revenues. However, over-dependence on such rents can lead to a phenomenon known as the "resource curse," where economies become overly reliant on a single sector, making them vulnerable to commodity price fluctuations and resource depletion, which can harm long-term economic stability and diversification efforts. Additionally, overexploitation of natural resources can have detrimental environmental consequences, undermining the sustainability of both the economy and the environment [24]. The relationship between GDP and sustainability metrics like Renewable Electricity Output, Renewable Energy Consumption, and Total Natural Resources Rents is a complex one, characterized by both positive and negative aspects. In order to achieve long-term sustainability goals while simultaneously addressing any obstacles and disruptions that may develop throughout the transition to a more sustainable and resilient economy, it is essential to strike the proper balance. This requires negotiating the trade-offs between short-term economic advantages and long-term sustainability goals [25]. Based on the explanation above, a hypothesis emerged in this research, namely (H1) GDP has a significant positive effect on Renewable Electricity Output, Renewable Energy Consumption, and Total Natural Resource Rents, and (H2) GDP has a significant negative effect on Renewable Electricity Output, Energy Consumption Renewable, and Total Natural Resource Rents.

3. Research Method

We use Vector Error Correction Model (VECM) analysis with data originating from the World Bank in the 1995-2019 period providing a powerful research methodology to gain insight into the complex relationship between this research variable namely GDP and key sustainability indicators such as Renewable Electricity Output, Renewable Energy Consumption, and Total Natural Resource Rent, with a special focus on Indonesia. This research approach allows for dynamic examination of the interactions between variables over time, capturing short-term and long-term dependencies and uncovering potential causal relationships. By applying VECM, this analysis can explain how a country's economic growth was affected by shifts in the use of renewable energy, utilization of natural resources, and related environmental impacts over this 25 year period. Ultimately, this research method empowers policy makers and researchers to better understand Indonesia's evolving sustainability landscape and devise strategies that align the economy. Systematically as follows:

$GDPt = \beta 0 + \beta 1REOt + \beta 2RECt + \beta 3TNRt + et$

$REOt = \beta 0 + \beta 1GDPt + \beta 2RECt + \beta 3TNRt + et$

$RECt = \beta 0 + \beta 1GDPt + \beta 2REOt + \beta 3TNRt + et$

$TNRt = \beta 0 + \beta 1GDPt + \beta 2REOt + \beta 3RECt + et$

Description:

GDP : GDP growth

REO : Renewable Electricity Output

REC : Renewable Energy Consumption

TNR : Total Natural Resources Rents

β : the magnitude of the effect of causality

e = Error term

t = Time period

eql: equation

3.1. VECM analysis

Vector Error Correction Model (VECM) are econometric techniques commonly used in time-series analysis to examine the dynamic relationships between multiple variables over time. VAR models allow researchers to capture the interdependencies among several variables simultaneously, making them valuable tools for investigating complex economic and financial systems. VECM, on the other hand, is an extension of VAR that is particularly useful when dealing with non-stationary time series data, where variables may exhibit long-term relationships. VECM models are commonly employed in studies related to cointegration and error correction, helping to uncover both short-term and long-term interactions between variables. These methodologies have widespread applications in various fields, including economics, finance, and environmental sciences, providing valuable insights into how different factors influence each other and evolve over time (See Table 1).

TABLE 1: Description of variables.

Variable	Explanation	Data type	Source
GDP growth	Total growth of GDP based on annual income	Percentage	World Bank
Renewable electricity output	Renewable electricity is the portion of total electricity generated by all types of plants that is generated by renewable power plants.	Percentage	World Bank
Renewable energy consumption	Renewable energy consumption is the proportion of renewable energy in total final energy consumption.	Percentage	World Bank
Total natural resources rents	The total rents from natural resources are made up of the hard and soft coal, mineral, oil, natural gas, and forest rents.	Percentage	World Bank

4. Result and Discussion

VECM stands for Vector Error Correction Model. It is a type of vector autoregressive model (VAR) that can be used to analyze the long-run and short-run dynamics of cointegrated variables. Cointegration means that some linear combinations of non-stationary variables are stationary, implying a long-run equilibrium relationship among them. VECM can capture both the long-run cointegration and the short-run adjustments to deviations from the equilibrium. To estimate a VECM, you need to determine the number of cointegrating equations and the lag order of the model. There are different methods for doing this, such as Johansen's test, Engle-Granger test, or information criteria. You also need to specify whether there are any deterministic terms in the model, such as constants, trends, or seasonal dummies. Stationarity is an important property of time series data. It means that the mean, variance, and autocorrelation of the series do not change over time. Stationary series are easier to model and forecast than non-stationary series. To test for stationarity, you can use various tests, such as Dickey-Fuller test, augmented Dickey-Fuller test, or Phillips-Perron test. If a series is non-stationary, you can try to make it stationary by differencing or transforming it. Table 2 show the result of stationary test.

Table 2: Stationary test.

Variable	Level		First Difference	
	Prob.	Description	Prob.	Description
GDP	0.0163	Fulfil	0.0001	Fulfil
REO	0.0270	Fulfil	0.0000	Fulfil
REC	0.2045	Not Fulfil	0.0000	Fulfil
TNR	0.5479	Not Fulfil	0.5479	Fulfil

Table 2 the stationary test through the unit root test to see stationary variables at a certain level. The result is that all variables are stationary at both level and first difference levels so that the problem of data stationarity is overcome. Lag testing to determine the length of the lag to be used, described in below this table 3.

Table 3: Lag optimum test.

Lag	LogL	LR	FPE	AIC
0	-374.6609	NA	5.95e+08	31.55507
1	-348.6986	41.10692*	2.66e+08*	30.72488*

From table 3 above the length of the lag used is lag 1. The cointegration test is carried out to check whether the VECM analysis can be used if cointegration is indicated, described in below this table 4.

Table 4: Cointegrating test.

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0,05 Critical Value	Probability
None *	0.783395	53.10280	47.85613	0.0148
At most 1	0.420992	17.92020	29.79707	0.5720
At most 2	0.183388	5.352123	15.49471	0.7703
At most 3	0.029661	0.692534	3.841466	0.4053

In table 4 it is known that the results of the cointegration test show that there is 1 cointegration so that the VECM test can be carried out, in table 5.

Based on the findings of the VECM analysis in table 5 above, there is a significant positive effect between GDP and REC with the t-statistic value [3.61854] greater than the t-table value of 1.7108. Apart from that, REO and GDP also have a significant positive influence on GG with a t-statistic value [3.58349] greater than the t-table value of 1.7108. Lastly, there is a significant positive relationship between REC and REO t-statistical value [2.02919] which is greater than the t-table value of 1.7108. Through these results, both

TABLE 5: VECM test result.

	D(GDP)	D(REO)	D(REC)	D(TNR)
D(GDP(-1))	-0.087347	0.012924	213.8229	0.060677
	(0.16509)	(0.09944)	(59.0909)	(0.08672)
	[-0.52908]	[0.12996]	[3.61854]	[0.69967]
D(REO(-1))	1.302167	-0.357789	-38.92698	-0.097998
	(0.36338)	(0.21889)	(130.064)	(0.19088)
	[3.58349]	[-1.63459]	[-0.29929]	[-0.51340]
D(REC(-1))	0.000448	0.000767	-0.250139	-0.000132
	(0.00063)	(0.00038)	(0.22452)	(0.00033)
	[0.71354]	[2.02919]	[-1.11409]	[-0.40148]
D(TNR(-1))	-0.536392	-0.442261	84.92723	-0.139152
	(0.51199)	(0.30841)	(183.258)	(0.26895)
	[-1.04765]	[-1.43402]	[0.46343]	[-0.51739]
C	-0.155983	0.099325	-122.7929	-0.156697
	(0.74319)	(0.44767)	(266.010)	(0.39040)
	[-0.20988]	[0.22187]	[-0.46161]	[-0.40138]

t-table value 1,7108

past GDP and Renewable Electricity Output, and Consumption of Renewable Energy have had a positive impact that mutually influence one another.

Determining the influence between variables can also be done by comparing the value of t-statistic and the value of the coefficient. From table 5 it can be seen that GDP and REO have a significant positive effect with a t-statistic value [0.12996] which is greater more than the coefficient (0.09944). In addition, GDP also has a significant positive effect on TNR t-statistic [0.69967] is greater than the coefficient (0.08672). Thus, the increase that occurred in GDP in the past will help increase Renewable Electricity Output and Total Natural Resources Rents. On the other hand, REO and TNR have a significant negative effect with a t-statistic value of [-0.51340] which explains that the increase in Renewable Electricity Output in the past actually reduced Total Natural Resources Rents. This also applies to the REC variable which has a relationship significant negative effect on TNR with a t-statistic value of [-0.40148]. However, REC has a relationship significant positive impact on GDP with a t-statistic value [0.71354] so that increasing renewable energy consumption will increase GDP. The influence impact between TNR and GDP is significantly negative with a t-statistic value of [-1.04765]. TNR also had a negative relationship effect on REO with a t-statistic value of [-1.43402].

Thus, the increase in Total Natural Resources Rents will reduce GDP and Renewable Electricity Output.

TABLE 6: Granger causality result.

Null Hypothesis:	Obs	F-Statistic	Prob.
REO does not Granger Cause GDP	24	2.58210	0.1230
GDP does not Granger Cause REO		0.34197	0.5649
REC does not Granger Cause GDP	24	1.00270	0.3281
GDP does not Granger Cause REC		6.31688	0.0202
TNR does not Granger Cause GDP	24	0.15372	0.6990
GDP does not Granger Cause TNR		0.02526	0.8752
REC does not Granger Cause REO	24	0.33760	0.5674
REO does not Granger Cause REC		0.00399	0.9502
TNR does not Granger Cause REO	24	0.05863	0.8110
REO does not Granger Cause TNR		0.14717	0.7051
TNR does not Granger Cause REC	24	2.37081	0.1386
REC does not Granger Cause TNR		1.42519	0.2459

Table 6 above is a causality Granger test conducted to see the causal relationship between variables. It can be seen that the unidirectional causality relationship only occurs in the GDP and REC variables with a probability value of 0.0202.

5. Conclusion, Limitation and Suggestion

5.1. Conclusion

GDP growth that occurred in the past also had a positive synergy effect on other variables in this research. Increasing GDP will also increase Renewable Electricity Output and Total Natural Resource Rentals. In addition, it also has the same impact on increasing Renewable Electricity Output and Renewable Energy Consumption which reduces Total Natural Resource Rent. However, a positive relationship occurs because increasing Renewable Energy Consumption also increases GDP. For total Natural Resource Rentals, the influence on GDP and Renewable Electricity Output is negative. In summary, this analysis provides valuable insight into the complex dynamics between GDP, Renewable Electricity Output, Renewable Energy Consumption, and Total Natural Resource Rent. These findings underscore the complex interrelationships between economic growth, energy sustainability and resource utilization, and emphasize the need for balanced and appropriate policy making to ensure economic prosperity and environmental management in the years to come.

5.2. Limitation

This research is limited by data accessibility availability and timeframe period.

5.3. Suggestion

Based on the findings of this analysis, there are several opportunities for future research, which offer opportunities to deepen our understanding of the complex interrelationships between economic growth, sustainability and resource management. First and foremost, it would be useful to undertake a more detailed study of the specific policy mechanisms driving positive synergies between GDP, Renewable Electricity Output, and Total Natural Resource Tenancy. Investigating the policy interventions or market dynamics that drive these relationships can provide valuable guidance for policy makers seeking to promote economic prosperity and environmental sustainability. In addition, considering the simultaneous effect of GDP on Renewable Electricity Output and Renewable Energy Consumption requires closer scrutiny. Future research may investigate the various factors and conditions that determine the direction and magnitude of these impacts. Understanding when and why an increase in GDP leads to higher adoption and production of renewable energy, and its impact on Total Natural Resource Tenancy, can provide important insights into pathways to greener and more sustainable economic growth. Additionally, an exploration of the temporal aspects of this relationship would be enlightening. Analyzing how these interactions evolve over time, especially in response to changes in the policy landscape or economic context, can provide input for adaptive strategies to promote sustainable development. Longitudinal studies that track the evolution of these variables can offer a more dynamic perspective on the complex dynamics observed in this analysis. In addition, extending the geographic scope of research beyond Indonesia to include other resource-rich countries with varying levels of economic development can provide a comparative perspective. Exploring how these relationships manifest in different contexts can yield valuable lessons and policy recommendations adapted to specific regional conditions. Lastly, as the global transition to sustainable energy and resource management intensifies, research exploring the implications of these findings for achieving broader environmental goals, such as carbon neutrality and biodiversity conservation, will be critical. Examining how sustainable economic growth, as expressed by GDP, aligns with broader environmental goals can contribute to a holistic understanding of the challenges and opportunities in realizing a more sustainable and resilient future.

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