Optimization of Green Economy Model to Accelerate Sustainable Development in Indonesia

Mutiara Annisa, Rusiadi, Bakhtiar Efendi, Lia Nazliana Nasution

Abstract

This study aims to analyze how the optimization of green economic models can accelerate sustainable development in Indonesia. Using quantitative methods based on secondary data for the period 2005–2023 and the Vector Autoregression (VAR) model approach, this study examines the simultaneous relationships between key economic variables which include green investment, inflation, energy consumption, human development index (HDI), and economic growth (GDP). The results of the Impulse Response Function (IRF) and Variance Decomposition analysis show that the contribution of green investment to economic growth and human development increases significantly in the medium and long term. Inflation has a negative impact on human development, while energy consumption shows stability but is beginning to be influenced by external factors in the long term. Economic growth is also increasingly dependent on social and environmental factors over time. These findings emphasize the importance of cross-sectoral integration, policy consistency, and strengthening the role of green investment in the national development framework. By adopting a measurable and sustainable green economy model, Indonesia can strengthen the foundation of economic transformation towards a more inclusive, equitable, and environmentally friendly economy.

Keywords: Green Economy, Sustainable Development, Green Investment, VAR, HDI, GDP

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2nd International Cofference on the Epicentrum of Economic Global Framework (ICEEGLOF)
Theme: Navigating The Future: Business and Social Paradigms in a Transformative Era.
https://proceeding.pancabudi.ac.id/index.php/ICEEGLOF/issue/view/9

Introduction

Modern economic development faces the dual challenge of encouraging growth to improve people's welfare while maintaining environmental sustainability. The concept of green economy emerged as a strategic response to this dilemma by integrating inclusive economic growth with ecological principles. An important advance in green economy efforts is the incorporation of digital technologies, which improve resource efficiency, expand access to green markets, and accelerate the transition to sustainable consumption and production (Adolph, 2025). Sustainable development is development that meets today's demands while maintaining the ability of future generations to meet their own needs. A stable and sustainable source of income, reduced resource depletion, and reduction of environmental damage are the goals of sustainable economic growth, which seeks to improve living standards. It is a holistic approach that links social and environmental progress with economic growth (Berstembayeva et al., 2024). The principles of the green economy encourage the use of resources in balanced proportions, avoid overuse, and strive to improve our environmental conditions and lifestyle. By reducing pressure on air, soil, and energy resources, green economy operations support a healthy environment(Rusiadi et al., 2024).

Indonesia faces a major challenge in maintaining a balance between rapid economic growth and environmental conservation. Conventional development models that focus on the exploitation of natural resources often result in environmental damage, social inequality, and irrenewable resource degradation. In the midst of this situation, the transition to a green economy is an urgent need. The green economy, which prioritizes sustainability through resource efficiency, reduced carbon emissions, and improved social welfare, offers solutions to ensure that Indonesia's development remains inclusive and sustainable. The importance of this research lies in the effort to understand the extent to which the concept of green economy can be adopted and applied in the context of Indonesia's development, which has geographical, demographic, and economic uniqueness that will later affect the welfare of the community (Ammar et al., 2024).

The topic of green economy has become a global concern, especially after the implementation of the Sustainable Development Goals (SDGs) by the United Nations in 2015. This concept integrates three main pillars, namely economic, environmental, and social, to create a more balanced development system. In Indonesia, the implementation of the green economy includes various initiatives, such as renewable energy development, energy efficiency, and sustainable waste management. However, this implementation still encounters various obstacles, ranging from limited regulations to lack of public awareness (Fahmi et al., 2024).

Consumers in the energy sector consume, produce, sell, exchange or store energy efficiently, leading to more sustainable industries and helping to achieve the energy targets set out in the Sustainable Development Goals. Green consumption has been the subject of popular cultural and academic studies over the past ten years, showing a major shift in consumers' perspectives on environmental issues, as well as generational differences in their willingness to sacrifice more for eco-friendly goods and services recognising that eco-friendly production and consumption should be a top priority in the Sustainable Development Goals, thus increasing research on eco-friendly consumerism milieu. This may be the reason why the importance of this topic is increasingly raised. It is stated that developed countries must change their consumption and production patterns, and developing countries must maintain their production patterns (Hutasoit, 2024)

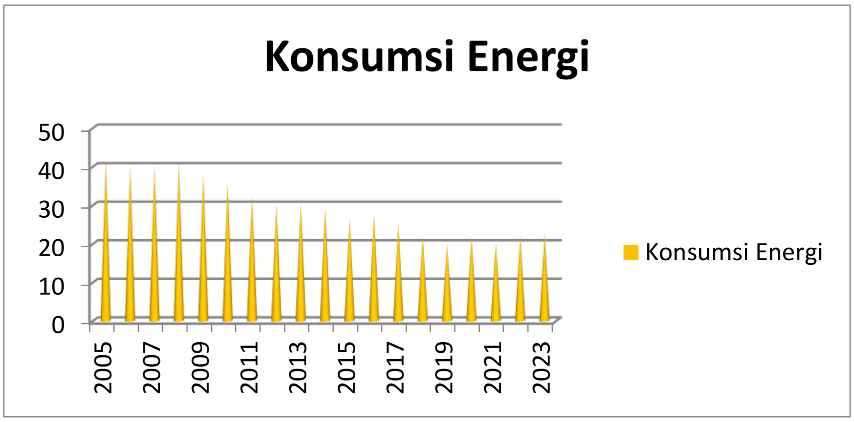

Figure 1. Energy Consumption Data in Indonesia in 2005-2023

Green Economy is a rapidly evolving concept in the context of global sustainable development with the aim of improving human welfare, promoting social justice, and significantly reducing environmental risks and ecological scarcity. In an era of environmental uncertainty and climate change that is increasingly worrying, the green economy is one of the solutions that is considered effective in balancing economic growth with environmental sustainability. This concept introduces an economic model that focuses on reducing negative impacts on the environment, efficient use of natural resources, and social inclusion that promotes shared well-being. In an increasingly complex global challenge, the Green Constitution's contribution in encouraging the Green Economy is becoming increasingly important. From the study of the relationship between energy consumption and economic growth, it is clear that energy consumption is the main driver of economic expansion. In addition to encouraging economic expansion, energy consumption also contributes to global environmental pollution, which is gradually becoming a significant issue that hinders the progress of sustainable economic growth. This research provides a theoretical foundation for coordinating energy consumption and economic growth by identifying the basic laws of economic growth and energy consumption, identifying turning points in energy consumption, and resolving internal contradictions between the two(Novianti, 2024)(Ulfa & Efendi, 2024).

The existence of a green economy aims to maintain a balance between improving people's welfare and maintaining the national economy. Therefore, in micro and macroeconomic development carried out by the government, the principles of the green economy must be adopted in its implementation. There are five principles of green economy-based economic development. First, the green economy must be able to create prosperity for the entire community. Second, it must be able to create equality for various generational periods. Third, it must be able to maintain, restore, and invest in various activities based on natural resources. Fourth, it is expected to be able to support sustainable consumption and production levels. Fifth, it must be supported by a strong, integrated, and accountable system (Anwar, 2022).

Green economy as a system that promotes welfare and social justice, while minimizing environmental threats and ecological deficits. This approach prioritizes the development of low-carbon economic systems, resource optimization, and social inclusivity. UNEP emphasizes the urgency of natural capital conservation, including ecosystems and natural resources. Thus, a green economy can be interpreted as a pattern of economic behavior that balances growth with environmental protection and the prevention of ecosystem damage, which leads to improved human and social welfare (Sa'idah et al., 2023). Historical review shows that the term green economy first appeared in the "Blueprint for a Green Economy" compiled by a group of economists for the British government in 1989. Then, this concept resurfaced in 2008 when UNEP advocated for "green stimulus" and identified strategic areas for large-scale public investment in the context of the implementation of the green economy. UNEP underlines that green investment needs to be supported through careful public spending planning, policy reform, and adjustment of the tax and regulatory system. This approach positions natural capital as a vital economic asset and a source of public benefit, especially for underprivileged communities that depend on natural resources (Novita Rahmawati & I.Ketut Bayangkara, 2024).

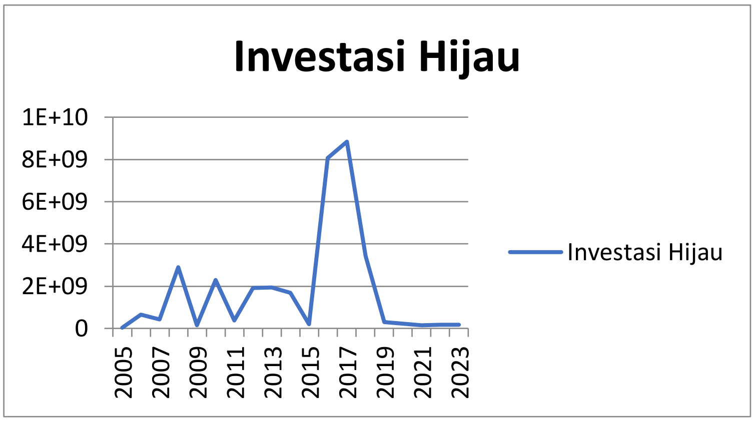

Figure 2. Green Investment Data in Indonesia in 2005-2023

In its implementation, the green economy is based on three fundamental principles. First, the low carbon principle emphasizes the reduction of greenhouse gas emissions through the adoption of environmentally friendly technologies and sustainable practices in economic activities. Second, the principle of resource efficiency that prioritizes the optimal and sustainable use of natural resources, including energy, water, and materials. Third, the principle of social inclusion that ensures the equitable distribution of economic development benefits to all levels of society, taking into account aspects of justice and common welfare. The implementation of these three principles requires collaboration between governments, the private sector, and communities in developing policies and practices that support the transition to a green economy. This includes investment in sustainable infrastructure, renewable energy development, effective waste management, and inclusive community empowerment programs (Afrida Rosa Marsela & Nurma Fitrianna, 2025).

Optimizing green economic models is the key to accelerating the transformation of sustainable development in Indonesia. By building and developing measurable and contextual models, governments and stakeholders can identify strategies for sectors with high green potential, measure the economic and environmental impact of each policy, and develop more adaptive development strategies. The model can also serve as an instrument for evaluating the performance of sustainable development, as well as a projection tool in planning a greener and more inclusive national economic future. Through this research, it is hoped that a conceptual and practical approach can be formulated in optimizing a green economy model that is not only academically relevant, but also applicable in the context of national development policies. Thus, Indonesia can not only achieve economic growth targets, but also strengthen the foundations that are the main foundation for long-term development.

Research Methods

The approach carried out by quantitative researchers is based on secondary data from the period 2005-2023 through the World Bank. The conceptual framework of the research is drawn as follows:

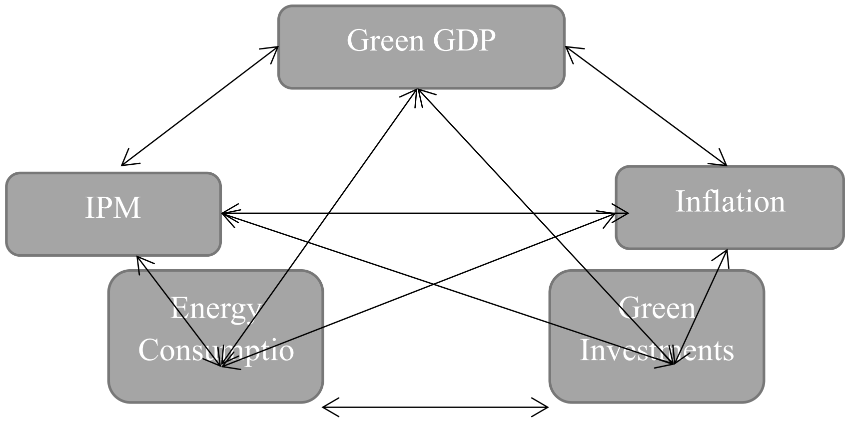

Figure 3. The Conceptual Framework of VAR

The conceptual framework image explains that the model used is the Vector Autoregression (VAR) test to analyze monetary policy in strengthening economic fundamentals in Indonesia by looking at the formation of vectors that affect each other. According to Manurung (2009) it is impossible to distinguish between endogenous and exogenous variables if the simultaneity between several variables is true. Testing of simultaneous relationships and degrees of integration between variables in the longterm using the VAR method is used because it is easier to use and to prove empirically and complexly the long-term reciprocal relationships of endogenous variables. The VAR analysis model consists of the following formula:

$$PDB_t = \beta_{10}\, PDB_{t-p} + \beta_{12}\, INF_{t-p} + \beta_{13}\, IPM_{t-p} + \beta_{14}\, KE_{t-p} + \beta_{15}\, IH_{t-p} + \beta + e_{t1}$$

$$INF_t = \beta_{10}\, PDB_{t-p} + \beta_{12}\, INF_{t-p} + \beta_{13}\, IPM_{t-p} + \beta_{14}\, KE_{t-p} + \beta_{15}\, IH_{t-p} + \beta + e_{t1}$$

$$IPM_t = \beta_{10}\, PDB_{t-p} + \beta_{12}\, INF_{t-p} + \beta_{13}\, IPM_{t-p} + \beta_{14}\, KE_{t-p} + \beta_{15}\, IH_{t-p} + \beta + e_{t1}$$

$$KE_t = \beta_{10}\, PDB_{t-p} + \beta_{12}\, INF_{t-p} + \beta_{13}\, IPM_{t-p} + \beta_{14}\, KE_{t-p} + \beta_{15}\, IH_{t-p} + \beta + e_{t1}$$

$$IH_t = \beta_{10}\, PDB_{t-p} + \beta_{12}\, INF_{t-p} + \beta_{13}\, IPM_{t-p} + \beta_{14}\, KE_{t-p} + \beta_{15}\, IH_{t-p} + \beta + e_{t1}$$

Where:

GDP = Green Economic Growth
INF = Inflation
IPM = Human Development Index
TO = Energy Consumption
IH = Green Investment
p = lag length

Next is the analysis of the Impulse Response Function (IRF) model, which is carried out to understand how each variable affects the standard deviation of innovation. Ariefianto (2012) explained that IRF conducts research related to the impact of shock on a variable in the system in a certain period of time. The purpose of the IRF analysis is to determine whether each transmission variable is integrated in both the short and long term. Manurung (2005) revealed that IRF is an indicator of a change in the direction of movement of transmission variables as a result of changes in other transmission variables. To find out how important the various shocks are to the variables themselves and the others, Forecast Error Variance Decomposition (FEVD) is used. Manurung (2005) stated that the purpose of FEVD analysis is to determine the contribution or influence between transmission variables.

The next analysis was carried out with an Assumption test consisting of the Data Stationerity Test (Unit Roots Test) and the Johansen Cointegration Test. Data stationarity can be obtained from data that was initially not stationary through testing the degree of integration or stationarity at the level of data differentiation. This process involves testing the availability of data stationarity at one level and then repeating the test at the differentiation level until it reaches a stationary state. Dickey-Fuller recommends the application of regression of certain models to determine the presence of unit roots in the data, as follows:

$$\Delta Yt = \theta Yt\text{-}1 + et \ (1)$$

$$\Delta Yt = \beta 1 + \theta Yt\text{-}1 + et \ (2)$$

$$\Delta Yt = \beta 1 + \beta 2t + \theta Yt\text{-}1 + et \ (3)$$

In equation (1), the variable that shows the difference in time trend is symbolized as t, and there are two additional regressions that include the constant and the variable of the time trend. Each model has two hypotheses taken into account: the zero hypothesis $\Theta = 0$, which indicates the unstationariness of the data, and the alternative hypothesis $\Theta < 0$, which indicates that the data is stationary. The DF statistic, represented by the t-value of the coefficient ΘYt-1, is compared to its critical value; the rejection of the null hypothesis occurs if the absolute value of the DF statistic exceeds the critical value, indicating that the observed data is stationary. Conversely, if the statistical value of DF is less than the critical value of the distribution t, then the data is considered non-stationary. Residual et and autocorrelation elements are often related and interrelated according to the assumptions in equations (1) and (2). Dickey Fuller later incorporated an autocorrelation element into his model, known as Augmented Dickey-Fuller (ADF) to develop a unit root test. This ADF test is generally used to assess the stationarity of data. The formulation of the ADF test can be described as follows:

$$\Delta\Delta Yt = \gamma Yt-1 + \sum \beta \Delta Yt-1+1 \ n \ t-1 + et \ (4)$$

$$\Delta Yt = \alpha 0 + \gamma Yt-1 + \sum \beta \Delta Yt-1+1 \ n \ t-1 + et \ (5)$$

$$\Delta Yt = \alpha 0 + \alpha 1T + \gamma Yt-1 + \sum \beta \Delta Yt-1+1 \ n \ t-1 + et \ (6)$$

Where:
Y = Research variable
Yt = Yt – Yt-1
T = Time trend
N = lag value

The process to assess whether or not the data is stationary involves comparing the statistical value of ADF with the value of the critical distribution of Mackinnon. The statistical t-value of the γYt-1 coefficient is given in equations (4 to 6). If the absolute value of the ADF statistic exceeds its critical value, then the observed data shows a stationary nature. Conversely, if the absolute value of the ADF statistic is smaller than its critical value, then the data is considered non-stationary. It is also important to determine the length of inaction in the ADF test, and the Aikake Information Criterion (AIC) or Schwarz Information Criterion (SIC) can be used for this purpose. The model with the lowest AIC and SIC values is considered the most suitable model. After knowing that the Export and Import data are stationary, the next step will determine if there is a long-term equilibrium relationship between the two. There is one direction of Granger's causality that is the most uncertain if the two variables integrate at degree one, I (1) and cointegrate. Based on the representation theorem, it is said that if a vector n/ (1) of the time-sequence data Xt cointegrates with the cointegration vector, then there is an error correction representation, which can mathematically be represented by: A (L). Xt = -yaXt-1 + β(L) εt (7) where: A(L) is a polynominal matrix in the lag operator with A (0) = I; Y is (nx1) a constant vector that is not equal to zero; β(L) is a polynominal scalar in L; and εt is the vector of the error variable that has white noise. In the short term, any deviation from the long-term equilibrium (a'X=0) will affect the change in Xt and will readjust towards equilibrium. The cointegration test that will be used here uses the test procedure.

Results And Discussion

The following is table 1. namely the root unit test with *augmented dickey fuller (ADF):*

Table 1. Test Unit Root Test with Augmented Dickey Fuller (ADF)

Variable	*Augmented Dickey Fuller*	
	t-statistic	Stationary
IH	**0.0065*** **	**1(1)**
INF	**0.0001*** **	**1(I)**
IPM	**0.0080*** **	**1(I)**
TO	**0.0003*** **	**2(1I)**
GDP	**0.0026*** **	**2 (II)**

Source: Data analysis, eviews 10

Description: ***, **, and * show significant at the level of 1%, 5% and 10%, respectively.

4.1 Co-Integration Test Results

Table 2. Co-Integration Test

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistics	0.05 Critical Value	Prob.**
None *	0.988838	144.2121	69.81889	0.0000
At most 1 *	0.884803	72.28790	47.85613	0.0001
At most 2*	0.811340	37.71012	29.79707	0.0050
At most 3	0.461792	11.02520	15.49471	0.2100
At most 4	0.067200	1.113025	3.841466	0.2914

Source: Data analysis, eviews 10

Table 2 above shows that the results of the cointegration test with the Johansen method were lower than the critical value. The trece statistic value and the maximum eigenstatistic value at r = 0 are lower than the critical value. This shows that there is no cointegration. The results show that cointegration in the variables Green Investment, Inflation and HDI has a stable and consistent relationship.

4.2 Optimal Lag Test Results

The results of Vector Autoregression (VAR) show that on a lag basis, vector autoregression analysis shows the contribution of each variable to the variable itself and the others, more clearly described in the following table:

Table 3. Vector Autoregression Results

Lag 1	Lag 2
Vector Autoregression Estimates Date: 05/18/25 Time: 12:22 PM Sample (adjusted): 2 18 Included observation: 17 after adjustments Standard errors in () &t-statistics in [] Determinant resid covatiance (dofadj.) 1.8620 Determinant resid covariance 2.1119 Log -489.8358 Infocriterion 62.21597 Schwarz criterion 63.686535 Number of coefficients 30	Vector Autoregression Estimates Date: 05/18/25 Time: 12:21 Sample (adjusted): 3 18 Included observation: 16 after adjustments Standard errors in () & t-statistics in [] Determinant resid covatiance (dofadj.) 7.2918 Determinant resid covariance 2.1716 Log -414.4559 Infocriterion 58.68199 Schwarz criterion 61.33776 Number of coefficients 55

Source: Data analysis, eviews 10

In Table 1. above, the VAR results show a Lag 1 AIC value of 62.21597 < a Lag 2 AIC value of 58.688199 also shows that the past variable (t-1) contributes to the present variable, both to the variable itself and to other variables. The analysts' results show that there is a reciprocal relationship between the variables. Next is the analysis of *the Impulse Response Function (IRF)* with the results described as follows:

Table 4. Summary of Impulse Response Function (IRF) Results

Response of INF: Period	INF	IH	IPM	TO	GDP
1	1.595567	0.000000	0.000000	0.000000	0.000000
5	2.580697	-1.972056	0.012708	0.680582	-1.559590
10	-0.828701	0.660559	1.426038	-1.429536	1.402042
Response of IH:					
Period	INF	IH	IPM	TO	GDP
1	-1.17E+09	2.94E+09	0.000000	0.000000	0.000000
5	-9.51E+08	-5.46E+08	-6.51E+08	-1.02E+08	-7.11E+08
10	4.26E+08	-2.94E+08	6.89E+08	-4.42E+08	8.25E+08
Response of IPM:					
Period	INF	IH	IPM	TO	GDP
1	0.885134	0.628047	0.747570	0.000000	0.000000
5	0.116955	-0.280047	0.097565	-0.064119	0.435201
10	-0.616153	0.345618	-0.528920	0.184111	-0.458986
Response of KE:					
Period	INF	IH	IPM	TO	GDP
1	1.069979	0.662034	0.196267	0.769439	0.000000
5	2.269097	-1.578403	0.550142	0.630716	-0.005703
10	1.573578	-0.889772	0.605313	0.232632	0.410824

Response of PDB:					
Period	INF	IH	IPM	TO	GDP
1	-0.251419	0.507725	0.302942	-0.225981	0.999826
5	0.873277	-0.905209	-0.506711	0.547761	-0.713949
10	-0.227527	0.275347	0.436374	-0.418130	0.011394

Source: Data analysis, eviews 10

Based on Table 2, the results show that the analysis shows that the inflation variable provides a positive response both in the short and medium term, which reflects its influence to provide a positive response both in the short and medium term, but in the long term has a negative response. Furthermore, the Green Investment (IH)variable provides a positive response in the short term and for the medium and long term has a negative response. Meanwhile,the HDI variable shows a different pattern, where in the short term and gives a positive response, but again becomes negative in the medium term. Consistent Energy Consumption variables provide a positive response in the short, medium, and long term. Finally, the GDP variable also shows a positive response in the short and long term but is responded negatively in the medium term.

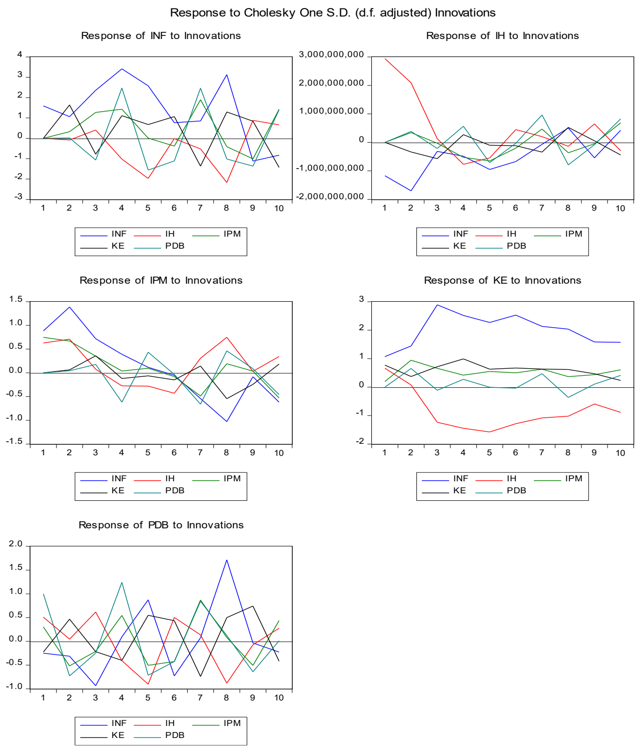

Figure 4. Graph Impulse Response Function (IRF)
Source: Data Analysis, Eviews 10

The image above is the result of the analysis Impulse Response Function (IRF) which describes the response of each variable to the shock of one standard deviation from another, using the Cholesky approach. The variables described include IH (Green Investment), KE (Energy Consumption), HDI (Human Development Index), INF (Inflation), and GDP (Economic Growth). This graph illustrates that there is a dynamic relationship between variables within the framework of sustainable development. Green investment has an impact on GDP and HDI, albeit to varying degrees and directions. Inflation is one of the variables that tends to have a negative impact on welfare, especially human development. This analysis provides an important understanding of how policies that drive the green economy can affect various economic and social aspects more comprehensively over time.

Table 5. Green Economy Interaction Accelerates Sustainable Development

Variable	Tennaga Kerja in Supporting Digital Economy Growth					Era
	INF	IH	IPM	TO	GDP	
INF	100%	-	-	-	-	Short-term
	53.93%	9.97%	7.39%	9.76%	18.94%	Medium term
	41.90%	11.65%	11.08%	12.83%	22.52%	Long-term
IH	13.60%	86.39%	-	-	-	Short-term
	25.20%	63.96%	3.75%	2.39%	4.68%	Medium term
	24.32%	53.56%	5.15%	4.09%	11.85%	Long-term
IPM	45.11%	22.71%	32.17%	-	-	Short-term
	53.40%	16.65%	18.03%	2.39%	9.50%	Medium term
	46.69%	18.49%	15.65%	5.35%	13.51%	Long-term
TO	51.71%	19.79%	1.74%	26.74%	-	Short-term
	66.63%	18.9%	5.33%	7.55%	1.48%	Medium term
	68.38%	18.36%	5.04%	6.54%	1.66%	Long-term
GDP	4.31%	17.61%	6.27	3.48%	68.30%	Short-term
	20.53%	18.42%	10.86%	8.81%	41.35%	Medium term
	29.84%	15.38%	13.10%	13.91%	27.76%	Long-term

Source: Author's processed data, 2025

: Largest 1

: Largest 2

The table shows the dynamic interactions between economic variables within the framework of a green economy to accelerate sustainable development, focusing on the contribution of each variable to the movement of other variables in three time periods: short-term, medium-term, and long-term. The five main variables analyzed include inflation (INF), green investment (IH), human development index (HDI), energy consumption (KE), and economic growth (GDP). In terms of inflation, in the short term, inflation is fully self-explanatory. However, as time goes by, the contribution of other factors such as GDP, energy consumption, and HDI begins to be significant. In the medium term, about half of the variation in inflation is still self-contained, but in the long term this proportion decreases to about 41%. This shows that in the long run, inflation is more complexly influenced by the dynamics of economic development and the environment. Green investing shows a strong dependence on itself in the short term, with almost 86% of its movements explained by the variable itself. However, in the medium and long term, it can be seen that the contribution of other variables such as HDI, energy consumption, and GDP is starting to increase, which indicates that the success of green investment in the long term is greatly influenced by its synergy with other development indicators. The human development index is a variable that is quite influenced by various factors in the short term. Although most of its variants are still self-explanatory, the contribution from inflation and green investment is also significant and increases in the medium and long periods. This reflects that human development is inseparable from macroeconomic stability and environmentally-oriented investment. Energy consumption is dominated by its influence over time, with a slight increase in the contribution of other variables such as green investment and HDI. This dependence suggests that energy consumption patterns tend to be stable and difficult to influence in the short term, but are starting to be open to external influences in the long term. Economic growth or GDP displays the most diverse structure in terms of its sources of variation. In the short term, most of its movement is self-explanatory, but the contribution of green investment and HDI continues to increase in the medium to long term. Interestingly, in the long term, the proportion of GDP's contribution to itself decreases to around 27%, while green investment and HDI have a greater role, which suggests that in the long run economic growth depends heavily on the social dimension and environmental desires. Overall, this table illustrates that accelerating sustainable development through a green economy approach requires time and mutually reinforcing cross-sectoral interactions. The effects of variables such as green investment, energy consumption, and inflation do not have a direct impact on the short term, but are starting to show a real influence in the medium and long term. Integration and continuity between variables are the key to success in realizing sustainable development in Indonesia.

Conclusion

This research shows that the optimization of green economic models has a strategic role in accelerating sustainable development in Indonesia. Through the VAR model approach and impulse response function, it was found that the relationship between variables such as green investment, energy consumption, human development index, inflation, and economic growth dynamically affect each other, both in the short, medium, and long term. Green investment has proven to make a positive contribution to economic growth and human development, especially in the medium and long term. Meanwhile, inflation tends to have a negative impact on the human development index if it is not properly controlled. Energy consumption, as an indicator of efficiency and economic activity, shows high stability but is starting to be open to the influence of green investment in the long term. Economic growth, which was initially dominated by internal contributions, in the long run is increasingly dependent on factors such as HDI and green investment. The results of the analysis also underlined that the transition to a green economy cannot be done instantly. Consistent cross-sector policy synergy, long-term planning, and support from various parties, including the government, the private sector, and the community are needed. With a measurable and systematic approach, the green economy model can be a solid foundation for Indonesia in achieving inclusive, equitable, and environmentally sound economic growth.

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