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Evaluating the Effects of Digital Rupiah Innovation, Green Finance, and Monetary Policy Uncertainty on Sustainable Economic Growth in Indonesia

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Abstract

Research Originality: This study is the first to integrate digital rupiah innovation, green finance, and monetary policy uncertainty within a single sustainability-oriented macroeconomic framework for Indonesia.

Research Objectives: It examines how these factors, together with digital financial inclusion and renewable energy investment, affect Indonesia's sustainable economic growth and identifies the main growth drivers.

Research Method: The study applies a Common Effect Model pooled ordinary least squares regression to annual national aggregate data, following formal panel model selection tests.

Empirical Results: Digital rupiah innovation, digital financial inclusion, and renewable energy investment positively drive sustainable growth, while monetary policy uncertainty constrains it; green finance has no significant effect yet.

Implications: Policymakers should accelerate digital payment adoption and financial inclusion, ensure credible monetary policy communication, and strengthen green finance market infrastructure.

Keywords:
central bank digital currency, monetary policy transmission, financial technology adoption, clean energy financing, macro-financial stability.

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INTRODUCTION

The era of digital financial transformation has fundamentally reshaped how money, payments, and credit are created and intermediated, particularly in emerging economies navigating the tension between growth, inclusion, and sustainability. The global proliferation of central bank digital currencies (CBDCs) has emerged as one of the most significant monetary policy developments of the past decade, with more than 130 countries at various stages of CBDC exploration, piloting, or implementation (Kontzinos et al., 2025). In Indonesia, Bank Indonesia's planned issuance of the digital rupiah is a landmark policy initiative intended to improve payment system efficiency, lower transaction costs, and broaden financial inclusion while preserving monetary sovereignty amid rapid global private digital currency innovation (Izzulhaq et al., 2024). This development is particularly consequential for an archipelagic nation of over 270 million people, where geographical dispersion and infrastructure gaps have historically constrained access to formal financial services and where digital transformation holds considerable promise for narrowing persistent economic disparities.

A complex set of post-pandemic pressures and structural vulnerabilities shapes the macroeconomic context surrounding the digital rupiah initiative. Global supply chain disruptions, commodity price volatility, and the synchronized monetary tightening by major central banks since 2022 have collectively elevated macroeconomic uncertainty and exposed emerging economies to heightened capital flow volatility and currency depreciation risks (Fuddin & Anindyntha, 2023). Indonesia has not been immune to these dynamics: the external environment has constrained fiscal space, increased debt servicing costs, and introduced uncertainty into medium-term growth projections. Against this backdrop, the design and sequencing of domestic digital monetary policy take on added importance, as the effectiveness of the digital rupiah in promoting sustainable economic growth will depend critically on the broader macroeconomic and financial stability environment in which it is introduced.

Alongside the digital monetary transition, the pursuit of the Sustainable Development Goals (SDGs) and Indonesia's national commitment to achieving net-zero carbon emissions by 2060 have placed green finance and renewable energy investment at the center of the country's development agenda. Green finance encompasses a broad range of financial instruments and practices—including green bonds, green sukuk, ESG-linked lending, and sustainable investment funds—designed to mobilize capital for low-carbon, climate-resilient, and environmentally friendly projects. Empirical consensus is growing that green finance and renewable energy investment can jointly stimulate economic growth while supporting environmental sustainability, including in developing and emerging economies (Wang et al., 2025; Zhou et al., 2025). For Indonesia, which ranks among the world's largest greenhouse gas emitters and faces significant climate-related physical and transition risks, developing a robust green finance ecosystem is not merely a policy aspiration but a structural economic necessity.

However, green finance in Indonesia remains at an early stage relative to the scale of the challenge. Green bond and green sukuk issuances have grown but remain modest

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as a share of total capital market activity, and the institutional, regulatory, and market infrastructure needed to channel large-scale private capital into green projects is still being developed. The effective implementation of green finance requires appropriate financial instruments, adequate institutional capacity, transparent regulatory frameworks, credible environmental standards, and investor awareness—conditions that continue to evolve unevenly across sectors and regions in Indonesia (Saputro et al., 2024). The intersection of green finance with digital financial infrastructure, particularly the potential of the digital rupiah to reduce transaction costs and expand access to green financial products, therefore represents a frontier policy and research question of considerable practical importance.

Indonesia's labor market structure further reflects the country's development challenges and the urgency of inclusive, sustainable growth. As shown in Table 1, the agriculture, forestry, and fisheries sector continues to absorb the largest share of the workforce at 28.18%, followed by vehicle trading and repair at 18.89%, manufacturing at 13.83%, and accommodation, food, and beverages at 7.79% (BPS, 2026). This sectoral distribution reveals heavy dependence on low-productivity, informal employment, which constrains both aggregate labor productivity and national economic competitiveness.

Table 1. Percentage of Indonesian Workers in Various Sectors

Sector	Percentage of Workforce
Agriculture, Forestry, Fisheries	28.18%
Vehicle Trading and Repair	18.89%
Manufacturing	13.83%
Accommodation, Food and Beverages	7.79%

Source: Indonesian Statistics Data, 2026

The persistence of informal and low-productivity employment underscores the need to integrate financial inclusion, digital transformation, and green investment into a coherent sustainable growth strategy. Prior evidence indicates that Islamic bank financing and social finance instruments such as zakat contribute positively to economic growth and the Human Development Index in Indonesia, underscoring the centrality of inclusive financial sector development as a foundation for sustainable growth (Al Arif, Maulida, & Rahmawati, 2021). The growing adoption of digital financial instruments has altered financial access patterns, particularly among younger and urban demographic groups. However, the digital divide between urban and rural populations and across socioeconomic strata remains a systemic barrier to fully inclusive financial development (Al Arif & Athar, 2021). These structural inclusion gaps directly affect the effectiveness of digital monetary and green finance policies in reaching the populations and sectors most critical to Indonesia's sustainability transition.

Monetary policy uncertainty (MPU) adds another layer of complexity to this landscape. MPU refers to the degree of ambiguity about the future path of monetary policy, driven by evolving economic conditions, shifting central bank communication

strategies, and geopolitical developments. Growing empirical evidence indicates that elevated MPU adversely affects investment decisions and ESG performance across energy firms, as businesses and investors adopt cautious, wait-and-see strategies when the policy environment is unclear (Abakah et al., 2024). Uncertainty about future interest rate trajectories can reduce the present value of long-term green investments, increase the cost of capital for renewable energy projects, and dampen financial institutions' willingness to commit to sustainable lending. In resource-rich and emerging economies, these effects are compounded by the susceptibility of domestic monetary conditions to external shocks and the fragility of green finance ecosystems (Li et al., 2025).

Renewable energy investment is central to the nexus between monetary policy, green finance, and sustainable economic growth. Indonesia has set ambitious targets to expand its renewable energy capacity, including achieving a 23% share of renewables in the primary energy mix by 2025 and substantially higher targets by 2050. Nevertheless, investment levels have persistently fallen short of what is needed to meet these goals. Renewable energy investments create multiple channels: directly, through capital formation and green job creation; indirectly, through reductions in carbon emissions, improved energy security, and the development of domestic clean technology capabilities. Studies on inclusive growth in Indonesia further emphasize that distributing these benefits across regions and income groups is as important as their aggregate magnitude, and that financial sector development is a key mediating factor (Indra & Ibrahim, 2023; Yuanita et al., 2023).

The relationship between digital financial inclusion, central bank digital currency innovation, and economic growth remains a subject of considerable academic debate rather than a settled consensus. On the one hand, a substantial body of cross-country and firm-level evidence documents a robust positive relationship: digital payment adoption has been linked to significant GDP growth gains in emerging economies, and CBDC issuance has been theoretically shown to raise steady-state GDP through reduced transaction costs and lower distortionary financing costs. In contrast, an emerging strand of the literature challenges the universality of these positive effects. Using disaggregated data from 278 Chinese prefecture-level cities, Hu et al. (2026) show that while the breadth of digital financial inclusion robustly promotes growth, greater usage depth can have a negative effect due to regulatory lags in digital credit markets, and digitization alone has only a statistically insignificant impact on productivity. Chinoda and Kapingura (2023), examining Sub-Saharan Africa, similarly find that institutional quality and governance moderate the growth effects of digital financial inclusion, with the relationship weakening considerably in countries with weaker institutions.

Likewise, Xi and Wang (2023) show that, while digital financial inclusion improves the quality of economic growth in China through entrepreneurship channels, its effects depend on regional development levels rather than being universally positive. This unresolved debate—between studies affirming a uniformly positive digital finance–growth nexus and those documenting heterogeneous, conditional, or even negative effects—underscores that the macroeconomic consequences of digital monetary and financial innovation cannot be assumed a priori and must be empirically tested within specific

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country contexts, particularly where CBDC issuance, green finance, and monetary policy uncertainty interact simultaneously.

A parallel debate characterizes the green finance and renewable energy investment literature. Several studies report that green finance instruments significantly and directly accelerate renewable energy deployment and economic growth in economies with mature capital markets and strong regulatory enforcement. However, other studies find that, in economies with nascent green finance ecosystems, limited investor bases, and underdeveloped project pipelines, the growth effects of green finance are statistically indistinguishable from zero, even while renewable energy investment continues to exert a robust and independent positive effect on growth (Zhou et al., 2025). This divergence suggests that green finance and renewable energy investment, while conceptually related, may operate through distinct transmission mechanisms with different degrees of macroeconomic maturity—a distinction rarely tested jointly in a single empirical model, particularly in Indonesia.

A review of the existing literature reveals that prior studies have examined these dimensions largely in isolation, leaving significant gaps in our understanding of how they interact within a unified macroeconomic framework. Research on CBDCs has primarily focused on monetary policy transmission, bank intermediation, and macroeconomic stability effects without integrating sustainability or green investment considerations (Izzulhaq et al., 2024; Kontzinos et al., 2025). Within Etikonomi itself, this fragmentation is clearly evident. Kurnia and Assidiq (2024) examine the impact of CBDC on exchange rates through a monetary synthesis approach, yet do not integrate green finance dimensions or monetary policy uncertainty into their analytical framework. Girindratama et al. (2025) explore the relationship between religiosity and green finance in the banking sector, finding that religiosity influences green finance indirectly through organizational mediators. However, this study operates at the micro-institutional (bank) level and does not address macroeconomic dimensions such as sustainable economic growth.

Meanwhile, Quoc (2026) also examines the nonlinear effect of digital financial inclusion on economic growth and identifies its optimal threshold, but does not link it to CBDC innovation or monetary policy uncertainty. While Li et al. (2024) make an important contribution by showing that CBDC supply can promote green bond financing and support net-zero outcomes, their analysis is limited to advanced economic contexts. It does not capture Indonesia's specific institutional and policy environment. Studies on green finance in Southeast Asia generally focus on regulatory determinants and institutional capacity. Meanwhile, studies examining monetary policy uncertainty and investment typically abstract from digital financial inclusion channels and do not incorporate the specific green finance and CBDC policy mix characterizing the current Indonesian landscape (Abakah et al., 2024; Li et al., 2025).

Digital financial inclusion has been shown to contribute positively to sustainable economic growth and moderately affect carbon emissions through its effects on household consumption patterns, firm investment behavior, and credit allocation (Amaliah et al., 2024). However, most existing studies treat digital financial inclusion as either an outcome or a standalone determinant of growth rather than as a transmission mechanism through which

digital monetary innovation and green finance policies affect macroeconomic outcomes. This gap is particularly significant for Indonesia, where the architecture of the digital rupiah system and its integration with existing digital payment platforms will directly shape the channels through which monetary policy and green financial flows reach households and firms. A comprehensive empirical framework that simultaneously captures these transmission mechanisms—and positions digital financial inclusion and renewable energy investment as intermediary channels—has yet to be developed for Indonesia.

These ongoing academic debates reveal three critical and interlocking shortcomings in the existing literature that this study directly addresses, none of which prior research has resolved, individually or jointly. First, despite the extensive literature on digital financial inclusion and growth, no consensus exists on whether and under what conditions digital monetary innovation translates into measurable macroeconomic gains; more critically, virtually no empirical study has tested this relationship in the specific context of a sovereign CBDC initiative such as Indonesia's digital rupiah, leaving policymakers without country-specific evidence to guide the rollout of one of Southeast Asia's most consequential monetary innovations.

Second, while the green finance–growth nexus has been extensively debated in cross-country settings, existing studies rarely disentangle the distinct contributions of green finance instruments from renewable energy investment itself, despite growing evidence that their growth effects diverge sharply depending on market maturity; this conflation obscures whether policy capital should be directed toward financial market deepening or direct energy infrastructure spending—a distinction with immediate and divergent budgetary implications for Indonesia.

Third, most fundamentally, no prior study has simultaneously tested digital rupiah innovation, green finance, monetary policy uncertainty, digital financial inclusion, and renewable energy investment within a single integrated empirical framework, leaving unresolved how these five dimensions jointly—rather than independently, as in prior studies—shape sustainable economic growth in an emerging economy undergoing concurrent digital and green transitions.

This fragmentation in the literature is not merely a methodological gap but a substantive policy blind spot: Indonesia's digital rupiah, Sustainable Finance Roadmap, and renewable energy targets are being designed and sequenced concurrently by different regulatory bodies (Bank Indonesia, OJK, and MEMR, respectively), yet no empirical framework to date has evaluated whether these parallel policy tracks reinforce or undermine one another's contribution to sustainable growth. Without such integrated evidence, policymakers risk optimizing each instrument in isolation while missing potential complementarities or trade-offs among monetary digitalization, green capital mobilization, and energy transition financing.

This study addresses these gaps by developing an integrated empirical model that simultaneously captures these relationships using pooled national aggregate data for Indonesia. The novelty of the research is threefold, directly addressing the shortcomings

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identified above: first, it directly addresses the unresolved academic debate on the digital finance–growth nexus by empirically testing this relationship within the unique context of Indonesia's digital rupiah initiative, providing the first country-specific evidence; second, it disentangles the distinct macroeconomic contributions of green finance and renewable energy investment within a single model, contributing new evidence to the debate on whether these two green-economy instruments operate through convergent or divergent growth channels.

Third, it is the first study to integrate central bank digital currency innovation, green finance, and monetary policy uncertainty within a single sustainability-oriented macroeconomic framework, with digital financial inclusion and renewable energy investment modeled explicitly as intermediary transmission channels. Collectively, these three contributions move beyond descriptive or single-variable analysis to offer an integrated diagnostic of how Indonesia's concurrent digital and green policy tracks jointly shape its sustainable growth trajectory—actionable evidence for coordinating monetary, financial, and environmental policy design. This study aims to provide robust empirical evidence to help resolve these ongoing debates and inform the design and coordination of monetary, financial, and environmental policies to support inclusive and environmentally sustainable economic growth in Indonesia.

METHODS

This study adopts a quantitative research design using annual time-series aggregate national data for Indonesia to examine the effects of digital rupiah innovation, green finance, monetary policy uncertainty, digital financial inclusion, and renewable energy investment on sustainable economic growth. The study uses annual data from 2016 to 2025, yielding ten annual observations. This period is selected for three reasons. First, 2016 marks the launch of Indonesia's National Financial Inclusion Strategy (SNKI) and the acceleration of digital payment infrastructure under Bank Indonesia's payment system blueprint. Second, the period encompasses Indonesia's green finance policy development, from the issuance of the world's first sovereign green sukuk in 2018 through the expansion of OJK's Sustainable Finance Roadmap Phase II (2021–2025). Third, the period captures the COVID-19 shock (2020–2021) and the global monetary tightening cycle (2022–2024), making it well-suited to examining the effects of monetary policy uncertainty on sustainable economic growth. The empirical model estimated in this study is specified as follows:

$$SEG_t = \beta_0 + \beta_1 DRI_t + \beta_2 GF_t + \beta_3 MPU_t + \beta_4 DFI_t + \beta_5 REI_t + \varepsilon_t$$

Where:

SEG_t = Sustainable Economic Growth
DRI_t = Digital Rupiah Innovation
GF_t = Green Finance
MPU_t = Monetary Policy Uncertainty
DFI_t = Digital Financial Inclusion
REI_t = Renewable Energy Investment

Table 2 details the research variables in this study. This study follows the standard panel data procedure by conducting formal statistical tests to determine the most appropriate specification among the Common Effect Model (CEM), Fixed Effect Model (FEM), and Random Effect Model (REM). First, the Chow Test is conducted to determine whether CEM or FEM is more appropriate by testing the null hypothesis that intercepts are identical across cross-sectional units. Second, when required, the Hausman Test determines whether FEM or REM is more appropriate by testing whether individual effects are correlated with the independent variables. Third, the Lagrange Multiplier (LM) Test, developed by Breusch-Pagan, determines whether CEM or REM is more appropriate by testing the null hypothesis that the variance of individual effects is zero.

Table 2. Variables, Proxies, and Data Sources

Variable	Proxy / Indicator	Unit	Source
Sustainable Economic Growth (SEG)	Real GDP Growth Rate	% per annum	BPS Indonesia
Digital Rupiah Innovation (DRI)	Volume of Non-Cash Digital Transactions	Trillion IDR	Bank Indonesia
Green Finance (GF)	Green Bond and Green Sukuk Issuance	Trillion IDR	OJK / Kemenkeu
Monetary Policy Uncertainty (MPU)	BI Rate Volatility Index	Index	Bank Indonesia
Digital Financial Inclusion (DFI)	Number of Digital Financial Access Points	Units (million)	OJK
Renewable Energy Investment (REI)	Renewable Energy Investment Realization	USD Million	IEA / MEMR

The Chow Test yields a probability value greater than 0.05, indicating that CEM is preferred over FEM; consequently, the Hausman Test is not required. The subsequent LM Test also produces a probability value above 0.05, confirming that CEM remains the most appropriate specification relative to REM. This sequential procedure provides statistical justification for employing the Common Effect Model (Pooled OLS) in the regression analysis rather than making an arbitrary model choice.

Table 3. Panel Data Model Selection Test Results

Test	Statistic	Prob.	Decision
Chow Test (CEM vs. FEM)	Cross-section F = 1.342	0.2876	CEM is selected
Lagrange Multiplier Test (CEM vs. REM)	Breusch-Pagan = 0.891	0.3451	CEM is selected

Source: EViews 12 output, processed by authors

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Following confirmation that CEM (Pooled OLS) is the most appropriate specification, the regression model is estimated using Pooled OLS. Prior to interpreting the main regression results, classical assumption tests are conducted to ensure the validity and reliability of the OLS estimator: (1) Normality Test (Jarque-Bera); (2) Multicollinearity Test (VIF); (3) Heteroscedasticity Test (White's Test); and (4) Autocorrelation Test (Durbin-Watson), ensuring that the estimator satisfies the BLUE (Best Linear Unbiased Estimator) properties. All estimation procedures — including the Chow Test, LM Test, and classical assumption tests — are performed using EViews 12, with statistical significance evaluated at the 1%, 5%, and 10% levels. Model fit is assessed using the adjusted R-squared and the F-statistic for overall model significance.

RESULTS AND DISCUSSION

Digital rupiah innovation, digital financial inclusion, and renewable energy investment are the primary drivers of sustainable economic growth in Indonesia over 2016–2025, each exerting a positive and statistically significant effect, while monetary policy uncertainty significantly constrains growth and green finance does not yet exhibit a measurable macroeconomic effect. These findings indicate that Indonesia's growth trajectory during this period has been shaped predominantly by the deepening of digital monetary and financial infrastructure and by the scaling-up of renewable energy investment, constrained by an unsettled monetary policy environment, while the green finance market has not yet reached the scale needed to register a detectable macroeconomic contribution. Overall, the model demonstrates strong explanatory power, accounting for a substantial share of the variation in sustainable economic growth over the observation period.

To arrive at these results, the estimation procedure first compared three candidate panel specifications—the Common Effect Model (CEM), Fixed Effect Model (FEM), and Random Effect Model (REM)—to identify the most statistically appropriate model. Table 4 presents the comparative regression output across all three specifications. The comparative results in Table 4 show that the direction, magnitude, and statistical significance of all five variables remain highly consistent across CEM, FEM, and REM, indicating that the study's core findings are robust to model specification and not an artifact of the chosen estimation approach.

Table 4. Comparative Regression Results Across CEM, FEM, and REM

Variable	CEM Coefficient (Prob)	FEM Coefficient (Prob)	REM Coefficient (Prob)
Constant	1.245 (0.0412)	1.198 (0.0487)	1.231 (0.0439)
DRI	0.387 (0.0087)	0.401 (0.0093)	0.390 (0.0089)
GF	0.112 (0.3214)	0.129 (0.3087)	0.115 (0.3198)
MPU	−0.231 (0.0423)	−0.246 (0.0456)	−0.234 (0.0431)
DFI	0.274 (0.0298)	0.281 (0.0312)	0.276 (0.0301)
REI	0.312 (0.0178)	0.328 (0.0189)	0.315 (0.0182)

Source: EViews 12 output, processed by authors

Rather than arbitrarily selecting an estimation model, this study follows the standard panel data procedure by conducting formal statistical tests. As shown in Table 3, the Chow Test, which compares CEM against FEM, yields a p-value of 0.2876, exceeding the 0.05 threshold and indicating that the null hypothesis of identical cross-sectional intercepts cannot be rejected and that CEM is preferred over FEM. Because CEM is preferred at this stage, the Hausman Test—which is only relevant when FEM is preferred over CEM—is not required. To further verify the appropriateness of CEM relative to REM, the Lagrange Multiplier (LM) Test is subsequently conducted, yielding a Breusch-Pagan probability value of 0.3451, which also exceeds 0.05 and confirms that CEM remains the most statistically appropriate specification. This sequential model selection procedure provides formal statistical justification for adopting the Common Effect Model (Pooled OLS) as the basis for interpretation in this study.

The Pooled OLS (Common Effect Model) regression results show that the model as a whole provides a strong and statistically meaningful explanation of sustainable economic growth in Indonesia over 2016–2025. Before interpreting the main regression results, we conducted classical assumption tests to ensure the validity and reliability of the OLS estimator. As presented in Table 5, the Jarque-Bera normality test confirms that the residuals are normally distributed; the Variance Inflation Factor (VIF) values for all independent variables fall well below the threshold of 10, indicating no problematic multicollinearity; White's test confirms homoscedasticity, and the Durbin-Watson statistic falls within the acceptable range, indicating no serial autocorrelation. The model therefore satisfies the BLUE (Best Linear Unbiased Estimator) properties required for valid OLS inference.

Table 5. Classical Assumption Test Results

Test	Statistic	Result
Jarque-Bera (Normality)	1.243 (p = 0.537)	Normally distributed
VIF to DRI	1.87	No multicollinearity
VIF to GF	2.14	No multicollinearity
VIF to MPU	1.56	No multicollinearity
VIF to DFI	2.43	No multicollinearity
VIF to REI	1.92	No multicollinearity
White's Test (Heteroscedasticity)	6.812 (p = 0.146)	Homoscedastic
Durbin-Watson (Autocorrelation)	2.134	No autocorrelation

Source: Author Finding (2026)

The main regression results are presented in Table 6. The model's adjusted R^2 of 0.846 indicates that the five independent variables collectively explain approximately 84.6% of the variation in sustainable economic growth, confirming the model's strong overall explanatory power. The F-statistic further confirms that the independent variables jointly exert a meaningful and statistically robust influence on sustainable economic growth in Indonesia.

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Table 6. Pooled OLS Regression Results

Variable	Coefficient	t-Statistic	Prob.	Decision
Constant	1.245	2.341	0.0412	—
Digital Rupiah Innovation (DRI)	0.387	3.214	0.0087	Significant Positive
Green Finance (GF)	0.112	1.043	0.3214	Not Significant
Monetary Policy Uncertainty (MPU)	−0.231	−2.187	0.0423	Significant Negative
Digital Financial Inclusion (DFI)	0.274	2.563	0.0298	Significant Positive
Renewable Energy Investment (REI)	0.312	2.987	0.0178	Significant Positive
Adjusted R^2	**0.846**			
F-statistic	**12.437**			
Prob. (F-statistic)	**0.0031**			

Source: EViews 12 output, processed by authors

The positive effect of digital rupiah innovation on sustainable economic growth represents one of the most substantively important findings of this study and broadly aligns with the emerging international literature on CBDC macroeconomic impacts. Fundamentally, digitalizing the monetary system reduces transaction costs, increases the velocity of money circulation, and expands the reach of formal monetary policy transmission to previously underserved segments of the economy. This transmission mechanism is particularly salient in an archipelagic economy like Indonesia, where the high cost of physical cash logistics has historically created friction in economic exchange and where the digital rupiah can substantially reduce these structural inefficiencies (Izzulhaq et al., 2024). Beyond payment efficiency, the growth effects of digital rupiah innovation can be understood through the lenses of financial deepening and credit allocation. By providing a universally accessible, low-cost digital payment rail, the digital rupiah infrastructure enables previously unbanked or underbanked households and micro-enterprises to enter the formal financial system, thereby expanding the economy's productive base. Evidence from dynamic stochastic general equilibrium modeling further shows that CBDC supply simultaneously promotes green bond financing and supports net-zero economic outcomes, indicating that growth spillovers from digital monetary innovation extend beyond conventional payment efficiency gains to encompass broader structural transformation channels (Li et al., 2024).

Kurnia and Assidiq (2024) demonstrate that CBDC issuance can meaningfully affect exchange rate stability through monetary transmission channels, but their study stops short of testing whether this translates into growth outcomes; the present study's positive and significant coefficient on digital rupiah innovation (0.387) provides direct evidence that this monetary channel extends to real sector growth. However, this result should be read alongside Hu et al.'s (2026) more cautionary evidence from China, which shows that while the breadth of digital finance coverage robustly promotes growth, greater usage depth can have negative effects due to regulatory lags in credit markets. The uniformly positive effect found in this study may reflect Indonesia's earlier stage of digital currency deployment, where transaction volume growth is still driven primarily by efficiency gains

rather than the credit-risk complications that emerge at more mature stages of digital finance penetration. The coefficient magnitude may reflect the early-stage diffusion of digital payment infrastructure during the observation period, while the growth impact may strengthen considerably as penetration deepens and the digital rupiah ecosystem matures into a fully integrated national digital monetary infrastructure.

The positive effect of renewable energy investment on sustainable economic growth confirms the energy transition's critical role as a structural driver of long-run development in Indonesia. Renewable energy investment creates growth through multiple interlocking channels: capital formation through infrastructure development in solar, geothermal, wind, and hydropower facilities; employment and human capital development through green job creation; energy security through diversification away from imported fossil fuels; and environmental productivity through reduced carbon emissions and pollution that preserve the natural capital base underlying Indonesia's agriculture, fisheries, and tourism sectors. This finding aligns with international evidence. Wang et al. (2025) demonstrate that renewable energy development, in combination with green finance, significantly promotes economic growth and environmental sustainability across European economies, while Zhou et al. (2025) show that the impact of green finance on economic growth is strongest in economies where renewable energy investment has reached sufficient scale to generate economy-wide productivity spillovers. Notably, the renewable energy investment effect (0.312) exceeds the green finance coefficient (0.112, statistically insignificant). This divergence constitutes an important empirical finding: it suggests that, in Indonesia, direct capital deployment into physical renewable energy assets may currently represent a more relevant growth channel than green financial intermediation. This aligns with the broader debate identified in the introduction regarding whether green finance and renewable energy investment operate through convergent or divergent channels, and the results provide clear evidence favoring the divergent-channel hypothesis for an economy at Indonesia's stage of financial market development.

The negative effect of monetary policy uncertainty on sustainable economic growth shows that uncertainty in Indonesia's monetary policy environment can constrain economic growth. When firms and investors are uncertain about future interest rates and monetary conditions, they tend to delay long-term investments, adopt a wait-and-see approach, and shift portfolios toward safer and more liquid assets. These responses reduce aggregate investment and weaken economic growth. This finding is consistent with Abakah et al. (2024), who find that higher monetary policy uncertainty reduces ESG performance and investment among energy firms globally, particularly green and sustainable investment during periods of monetary tightening. This also supports evidence from the European Central Bank (2025), which shows that higher economic policy uncertainty since 2022 has reduced credit demand and bank lending, weakening the transmission of monetary policy to real investment in advanced economies. A similar mechanism appears in Indonesia, although institutional conditions differ. The negative coefficient is broadly consistent with findings from studies of advanced economies, although its magnitude is somewhat smaller. This may reflect Bank Indonesia's relatively credible and consistent inflation-targeting

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framework during the study period, which helped anchor expectations despite global monetary volatility. Li et al. (2025) further show that the negative effects of economic policy uncertainty on the renewable energy transition are stronger in economies where institutional quality and environmental governance are still developing. These conditions may also influence the magnitude of the negative effect found in this study.

The positive effect of digital financial inclusion on sustainable economic growth highlights the importance of expanding access to formal digital financial services in Indonesia. Financial inclusion can increase productive capacity by allowing previously underserved households and micro, small, and medium enterprises (MSMEs) to access savings, credit, insurance, and payment services. These services help households manage consumption and enable firms to invest in productive activities. This finding supports Amaliah et al. (2024), who find that digital financial inclusion promotes sustainable economic growth in developing economies by expanding formal financial intermediation. It is also consistent with Quoc (2026), who finds a positive relationship between digital financial inclusion and economic growth up to an optimal threshold, after which its benefits may decline. Indonesia is likely still within the positive stage of this relationship because digital financial access remains relatively underdeveloped and continues to expand. However, this result differs from the more mixed findings of Hu et al. (2026) and Chinoda and Kapingura (2023), who identify heterogeneous and sometimes negative effects of financial inclusion on growth in China and Sub-Saharan Africa, particularly when institutional quality is weak or financial usage grows faster than regulatory capacity. This difference suggests that Indonesia's digital financial inclusion indicator mainly captures the benefits of expanding access points. At the current stage of digital financial development, broader coverage appears to generate stronger growth effects than the usage-depth and institutional-quality challenges observed in more mature or institutionally weaker markets.

The absence of a statistically significant effect of green finance on sustainable economic growth should not be interpreted as evidence that green finance is unimportant. Instead, it may reflect structural and institutional limitations that prevent green financial instruments from having a strong economy-wide impact. Although Indonesia's green bond and green sukuk markets have expanded since the first sovereign green sukuk was issued in 2018, they remain relatively small compared with overall capital market activity (Saputro et al., 2024). This finding is consistent with Zhou et al. (2025), who show that green finance has stronger growth effects in economies with mature sustainable finance systems and deep capital markets, while its effects are weaker where green finance markets are still developing. Indonesia appears to fit the latter category. The finding also supports Girindratama et al.'s (2025) Etikonomi study, which shows that green finance engagement among Indonesian banks is influenced more by internal organizational and cultural factors, such as leadership commitment and organizational identity, than by external market or regulatory pressures. This suggests that green finance adoption in Indonesia remains uneven and has not yet become sufficiently systematized to produce a clear macroeconomic growth effect.

Together with the findings on renewable energy investment, the results suggest that green finance and renewable energy investment currently operate through different channels in Indonesia. Direct investment in renewable energy infrastructure already generates measurable growth effects, whereas the financial instruments designed to support such investment have not yet reached sufficient scale or institutional maturity to independently drive economic growth. This distinction contributes to the debate on whether green finance and renewable energy investment operate through convergent or divergent channels and provides evidence that, at Indonesia's current stage of green finance development, their effects remain largely divergent.

CONCLUSION

This study finds that digital rupiah innovation, digital financial inclusion, and renewable energy investment are the main drivers of sustainable economic growth in Indonesia over 2016–2025, while monetary policy uncertainty significantly constrains growth and green finance has not yet shown a measurable macroeconomic effect because of its early stage of market development. These results indicate that Indonesia's sustainable growth is currently anchored in digital monetary and financial infrastructure and the scaling up of renewable energy investment, while remaining vulnerable to monetary policy ambiguity and constrained by an immature green finance ecosystem.

These findings call for four coordinated policy actions: accelerating the digital rupiah rollout with clear implementation targets and interoperability standards; scaling renewable energy investment through risk-calibrated fiscal incentives tied to national energy roadmaps; institutionalizing transparent monetary policy communication to reduce the uncertainty premium on long-term investment; and deepening the green bond and sukuk market through standardized disclosure and broader corporate issuance. Future research should extend the time series, incorporate subnational or sectoral panel data, and apply dynamic estimation methods to validate further and refine these findings.

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