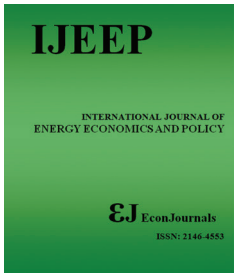

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Macroeconomic Determinants and Green Assets in Explaining Stock Return Dynamics: Evidence from Indonesia

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ABSTRACT

This study examines the effects of macroeconomic variables—interest rates, inflation, and exchange rate fluctuations—on green stock returns in Indonesia, highlighting the moderating role of green assets. Using firm-level data from 111 companies listed in the ESG Quality 45 Index (IDX KEHATI) during 2021–2023, the analysis integrates macroeconomic fundamentals with sustainability-linked financial indicators to capture market sensitivity to economic shocks. The results reveal that interest rates and inflation exert negative and statistically significant effects on green stock returns, while exchange rate fluctuations are insignificant. Green assets, however, enhance market performance and resilience, particularly under inflationary conditions. The positive interaction between inflation and green assets indicates that sustainability-oriented investments serve as an effective hedge against inflation. The model explains approximately 42% of the variation in returns and remains robust across lagged estimations. These findings extend the Arbitrage Pricing Theory by incorporating sustainability-based risk factors grounded in the Fisher Effect and Green Premium Hypothesis, emphasizing the strategic importance of green finance in strengthening market stability and supporting the transition toward a low-carbon economy.

Keywords: Green Assets, Interest Rate, Inflation, Exchange Rate, Emerging Markets, Sustainable Finance
JEL Classifications: E31, E43, F31, Q56

1. INTRODUCTION

Heightened global concern for environmental sustainability has profoundly reshaped investment behavior and the governance of capital markets. Investors increasingly favor sustainability-oriented financial instruments to address the challenges of climate change, energy transition, and responsible resource management (Flammer, 2021; Zerbib, 2019). The integration of Environmental, Social, and Governance (ESG) principles into financial decision-making has increased the appeal of green investments, as reflected in the growing issuance of green bonds, equities, and other sustainability-linked assets that finance renewable energy, clean transportation, and biodiversity initiatives (Sinha et al., 2024; Ng et al., 2021). Beyond their environmental contribution, these instruments exhibit distinct risk–return characteristics compared with conventional assets, underscoring their expanding role in global financial systems (Saeed et al., 2022).

The rising flow of sustainable investments signals a structural transformation in investor preferences, positioning ESG criteria as a fundamental determinant of portfolio allocation (Broadstock and Cheng, 2019; Flammer, 2020). Globally, green bond issuance reached USD 517.4 billion in 2021, driven by commitments to achieve net-zero emissions under the Paris Agreement (Climate Bonds Initiative, 2021), Indonesia has followed this global momentum, reflecting an increasing commitment to align capital market development with sustainability principles. This commitment is evident in the introduction of the SRI-KEHATI Index, IDX ESG Leaders, and the Sustainable Finance Roadmap Phase II (2021–2025) by the Financial Services Authority (OJK)

(Kehati, 2021). Collectively, these efforts demonstrate that sustainability integration has become a defining and irreversible feature of capital market evolution—both globally and within Indonesia.

Despite this progress, green financial instruments remain exposed to macroeconomic fluctuations such as inflation, interest rate movements, and exchange rate volatility. Previous studies have documented spillover effects between green and conventional markets, particularly during periods of financial stress (Lin and Su, 2022). However, much of the literature focuses on green bonds (Baker et al., 2018; Tang and Zhang, 2020; Wang et al., 2020) or on co-movement among green asset classes (Huynh et al., 2020; Reboredo et al., 2020). Consequently, limited evidence exists on how macroeconomic uncertainty affects green equity performance—an important omission given that inflation, interest rates, and exchange rates fundamentally influence investor behavior, capital costs, and asset valuation (Pham et al., 2020).

From a theoretical standpoint, the Fisher Effect (Fisher, 1930) posits that higher inflation leads to higher nominal interest rates, thereby reducing the present value of financial assets (Mishkin, 2007). Complementing this, the Arbitrage Pricing Theory (APT) (Ross, 1976) identifies macroeconomic variables such as inflation, interest rates, and exchange rates as systematic factors influencing expected returns. Meanwhile, the Green Premium Hypothesis (Zerbib, 2019) suggests that investors may accept lower returns on green assets due to their embedded environmental and social benefits (Baker et al., 2018). Although these theoretical frameworks are well established in green bond studies, empirical validation within green equity markets—especially in emerging economies—remains scarce. This gap is critical given the growing importance of green equities as stabilizing instruments amid macroeconomic uncertainty.

To address this gap, this study investigates the effects of interest rates, inflation, and exchange rate fluctuations on green stock returns in Indonesia, while analyzing the moderating role of green assets. This framework provides a comprehensive understanding of how sustainability-linked investments interact with macroeconomic forces to influence market performance and resilience. The Indonesian context—characterized by its commitment to a low-carbon transition—offers valuable insights into the dynamics of green finance within an emerging market framework.

Empirical evidence indicates that green stocks respond differently to macroeconomic shocks compared with conventional equities, primarily due to their longer investment horizons, regulatory support, and sensitivity to environmental policies (Yang et al., 2024; Lin and Su, 2022). Interest rate movements affect capital costs and firm valuation (Bauer et al., 2025), while exchange rate volatility influences the competitiveness of export-oriented green firms (Huong, 2025). Within this context, green assets are expected to act as stabilizers that cushion external shocks and sustain market confidence (Flammer, 2021; Zhang et al., 2022). Nevertheless, most prior research remains concentrated in developed markets and green bond segments, leaving the interaction between macroeconomic factors and green assets in emerging equity markets largely unexplored (Reboredo et al., 2020; Huynh et al., 2020; Liu et al., 2020).

Based on the empirical analysis, the findings reveal that both macroeconomic variables and green assets significantly explain variations in green stock returns. Interest rates and inflation exert negative effects, consistent with the Fisher Effect and APT, while green assets positively influence performance, underscoring their stabilizing capacity under inflationary pressures. Exchange rate effects are statistically insignificant, likely due to firms' effective currency risk management through hedging mechanisms (Bartram and Bodnar, 2007). Moreover, the interaction between inflation and green assets supports the inflation-hedging capability of sustainable financial instruments (Nguyen et al., 2021; Kong et al., 2023). The model explains approximately 42% of stock return variation, with robustness tests confirming the consistency of results.

Theoretically, these findings extend the APT by demonstrating that green assets can mitigate inflation risk but remain less responsive to monetary and exchange rate shocks. Practically, the results underscore the strategic importance of incorporating green assets into portfolio diversification and financial policy frameworks to strengthen market resilience. These insights are particularly relevant in the context of global macroeconomic uncertainty and Indonesia's ongoing transition toward a low-carbon economy. These findings form the empirical foundation for the subsequent discussion, which interprets the observed relationships within the frameworks of the Arbitrage Pricing Theory, the Fisher Effect, and the Green Premium Hypothesis.

This study contributes to the literature in three main ways. First, it integrates the Fisher Effect, APT, and Green Premium Hypothesis into a unified analytical framework, extending traditional asset pricing models to include sustainability dimensions. Second, it introduces green assets as a moderating construct—an innovative theoretical approach that advances sustainable finance research. Third, it shifts empirical focus from green bonds to green equities by employing firm-level green stock returns as the dependent variable. These contributions provide theoretical refinement and empirical validation of how sustainability-oriented instruments interact with macroeconomic forces in shaping asset pricing behavior across emerging markets.

The remainder of this paper is structured as follows: Section 2 outlines the theoretical framework, Section 3 details the methodology, Section 4 presents the empirical results, and Section 5 discusses policy implications and future research directions.

2. LITERATURE REVIEW

The Fisher Effect (Fisher, 1930) posits that rising inflation increases nominal interest rates, thereby reducing the present value of financial assets (Mishkin, 2007). Similarly, the Arbitrage Pricing Theory (APT) by Ross (1976) identifies inflation, interest rates, and exchange rates as systematic macroeconomic factors that determine expected returns, emphasizing their central role in asset

pricing. Complementing these frameworks, the Green Premium Hypothesis (Zerbib, 2019) suggests that investors may accept lower returns on green instruments due to their environmental and social value, extending portfolio theory to incorporate sustainability considerations (Baker et al., 2018). Within this foundation, green assets—such as green bonds, equities, and ESG-linked indices—play a dual role by channeling capital toward environmentally responsible projects while enhancing resilience to macroeconomic shocks (Flammer, 2021; Saeed et al., 2022; Zhang et al., 2022).

Despite their growing prominence, empirical evidence shows that green financial instruments remain vulnerable to macroeconomic fluctuations, as inflation, interest rates, and exchange rate changes influence investor sentiment and return expectations (Jin et al., 2019; Duan et al., 2023). While numerous studies examine green bonds, relatively few explore how these macroeconomic forces affect green equity performance, particularly in emerging markets. This gap is notable in countries like Indonesia, where ESG integration is accelerating amid heightened macro-financial volatility. Among these factors, interest rates are particularly critical as they directly influence capital costs, investment feasibility, and market valuation—making them a key determinant of green stock performance.

2.1. Interest Rates and Green Stocks

The Fisher Effect argues that nominal interest rates incorporate both expected inflation and real returns, implying that monetary tightening directly influences asset valuations (Fisher, 1930; Mishkin, 2007). As borrowing costs rise, the present value of future earnings declines, discouraging investment and lowering equity valuations—an especially significant challenge for capital-intensive green industries reliant on external financing. Hence, higher interest rates may constrain renewable energy investment and hinder the growth of sustainability-oriented firms.

Empirical studies confirm this theoretical link. Increases in interest rates raise the levelized cost of electricity (LCOE) for renewable projects, eroding their competitiveness against fossil fuels (Schmidt et al., 2019; Egli et al., 2018). Similarly, Agoraki et al. (2022) find that interest and inflation rates strongly influence asset performance in capital-intensive sectors. Policy developments, such as monetary stability and green financing incentives, are therefore vital to the success of the low-carbon transition (OECD, 2024). Moreover, stochastic and regime-switching models show that monetary uncertainty significantly shapes renewable investment behavior (Detemple et al., 2024).

Cross-market analyses further reveal that rising policy rates increase discount rates, leading to lower green equity valuations (Flammer, 2020; Aquila and Wullweber, 2024). Yet, few studies examine how sustainability-linked instruments could buffer these effects. Given their long-term orientation and investor confidence appeal, green assets may partially stabilize markets under tighter monetary conditions.

H_1: Interest rates negatively affect green stock returns.

2.2. Inflation and Green Stock Returns

Inflation is a key macroeconomic force shaping asset valuation and investment behavior. According to the Fisher Effect (Fisher, 1930), nominal rates adjust to inflation expectations to preserve real returns. Rising prices elevate discount rates, lowering the present value of cash flows and reducing asset prices (Mishkin, 2007). Within the APT framework (Ross, 1976), inflation represents a systematic risk factor affecting production costs, consumption, and monetary policy expectations, thereby diminishing real returns.

In green financial markets, inflationary impacts are more complex. Green industries—such as renewable energy and sustainable infrastructure—are capital-intensive and highly sensitive to material, financing, and technology costs Broadstock and Cheng (2019). Inflation increases production and borrowing expenses, reducing the net present value of projects and discouraging new investments (Egli et al., 2018). Thus, inflation tends to exert stronger pressures on environmentally focused sectors.

Empirical evidence consistently shows that rising inflation dampens equity returns and heightens uncertainty (Rjoub et al., 2017; Yahya and Hafasnuddin, 2021). For renewable firms, higher inflation erodes competitiveness (Lin and Su, 2022). However, firms with strong ESG integration exhibit greater resilience due to enhanced investor trust (Nguyen et al., 2021; Kong et al., 2023). This suggests that sustainability-oriented companies can partially hedge inflation risk through reputational and governance advantages.

Nonetheless, findings remain mixed. Some scholars argue that investors continue to favor sustainable sectors during inflationary periods due to ethical and strategic motives (Flammer, 2021;Broadstock and Cheng (2019), while others claim that inflation curtails green investment by prompting monetary tightening (Huong, 2025; Bauer et al., 2025). These contrasting views highlight the need for further evidence in emerging markets where inflation volatility and institutional conditions differ substantially.

H_2: Inflation negatively affects green stock returns.

2.3. Exchange Rates and Green Stock Returns

Exchange rate movements affect trade competitiveness, import costs, and capital flows, influencing the financial performance of green investments. Currency depreciation raises the domestic cost of imported renewable technologies—such as turbines and solar modules—thereby increasing both operating (OPEX) and capital expenditures (CAPEX) (Dornbusch, 1980; Goldberg and Knetter, 1997). Such cost pressures erode profitability, reduce cash flow stability, and weaken valuations in green sectors.

Empirical studies corroborate these dynamics. Yang et al. (2024) show that currency depreciation deters green investment in Europe, while Agoraki et al. (2022) and Lv et al. (2021) find that industries dependent on imported inputs exhibit heightened sensitivity to exchange rate volatility. Evidence from Asian markets (Yu et al., 2021; Jin et al., 2019) confirms that depreciation increases return volatility and compresses profit margins in sustainability-oriented firms.

However, most research overlooks behavioral aspects—such as investor confidence—or the potential mitigating role of green

assets. Because import cost shocks typically outweigh export gains, firms with significant foreign liabilities face heightened risk (Egli et al., 2018; Kolbel et al., 2020). Consequently, exchange rate fluctuations can amplify required risk premiums for green equities.

H_3: Exchange rate fluctuations negatively affect green stock returns.

2.4. Green Assets as Moderating Variables in Macroeconomic Relationships

The integration of ESG principles into global finance has strengthened the role of green assets—such as green bonds and ESG-linked equities—as potential stabilizers amid macroeconomic volatility. While higher interest rates and inflation typically raise financing costs and depress asset values, the Green Premium Hypothesis posits that sustainability-oriented investors may accept lower returns in exchange for long-term stability and social value (Zerbib, 2019; Baker et al., 2018)). Consequently, green assets may buffer adverse macroeconomic shocks by providing resilience and market confidence.

2.4.1. Green assets, interest rates, and green stock returns

Higher interest rates increase borrowing costs and lower the present value of future cash flows, exerting downward pressure on stock valuations—an effect particularly pronounced for capital-intensive green firms. However, firms with larger green portfolios tend to be more resilient to interest rate fluctuations, supported by instruments such as green bonds, concessional loans, and sustainability-linked subsidies that help sustain liquidity and investment capacity during periods of monetary tightening (Aquila and Wullweber, 2024). At the macro-policy level, initiatives such as green quantitative easing (QE) and targeted refinancing schemes provide preferential credit access to sustainable sectors, although their effectiveness depends on institutional quality and regulatory consistency (Lin and Su, 2022). Empirical evidence shows that firms in mature green finance markets maintain stronger performance under monetary stress, while those in emerging economies—where ESG financing remains limited—exhibit weaker resilience (Flammer, 2021; Lin and Su, 2022).

H_4: Green assets mitigate the negative effect of interest rates on green stock returns.

2.4.2. Assets, inflation, and green stock returns

The Green Premium Hypothesis suggests that investors' preference for sustainability-oriented assets allows green firms to preserve higher valuations even during inflationary periods (Kolbel et al., 2020). This valuation advantage implies that green assets may serve as a natural hedge against inflation by maintaining investor confidence and broadening access to lower-cost financing channels. However, inflation simultaneously raises production and financing costs—especially in capital-intensive sectors such as renewable energy—thereby compressing profit margins and reducing the perceived green premium (Aquila and Wullweber, 2024; Lin and Su, 2022). Consequently, the extent to which green assets stabilize firm value under inflationary conditions depends on firms' financial structures, market maturity, and investor commitment to sustainability principles.

Empirical findings remain mixed. TN-Lan et al., (2023) show that global inflationary shocks heighten funding risks for sustainable projects, whereas Montague et al. (2024) find that firms with larger green portfolios demonstrate stronger resilience to inflation. Similarly, Kolbel et al. (2020) and Yu et al. (2021) observe that green-oriented firms retain valuation premiums during inflationary cycles, benefiting from reduced cost volatility and stable long-term investor bases. Duan et al. (2023) further note that green assets enhance access to concessional financing aligned with global decarbonization initiatives. Collectively, these findings indicate that green assets can partially cushion inflation risk by stabilizing firm performance and mitigating cost pressures, though this effect is often weaker in emerging markets where inflation volatility and ESG financing constraints are more pronounced.

H_5: Green assets mitigate the negative effect of inflation on green stock returns.

2.4.3. Green assets, exchange rates, and green stock returns

Exchange rate fluctuations influence firm valuation and investment performance through changes in import costs, trade competitiveness, and capital flows. Currency depreciation raises the domestic price of imported renewable energy equipment—such as solar panels and wind turbines—thereby increasing production and financing costs that erode profitability in capital-intensive green sectors (Dornbusch, 1980; Goldberg and Knetter, 1997). However, according to the Green Premium Hypothesis, firms with substantial green portfolios are better positioned to mitigate these adverse effects, as investor preference for ESG-aligned assets enhances access to diversified, lower-cost financing and strengthens valuation stability during periods of currency volatility (Baker et al., 2018; Zerbib, 2019).

Empirical findings show that firms benefiting from international green financing—such as green bonds or climate-linked concessional loans—demonstrate greater resilience to exchange rate shocks by stabilizing capital costs and sustaining investor confidence (Flammer, 2021;Wang et al., 2020). Conversely, companies operating in emerging economies, where green financial infrastructure remains underdeveloped, face greater exposure to currency-induced risks due to limited access to hedging instruments and sustainable funding sources (Lin and Su, 2022). These differences highlight that the moderating role of green assets depends on market maturity, policy support, and integration with global sustainable finance networks.

H_6: Green assets mitigate the negative effect of exchange rate depreciation on green stock returns.

3. RESEARCH METHODOLOGY

3.1. Research Design

This study employs a quantitative explanatory design to examine how macroeconomic variables—interest rates, inflation, and exchange rates—influence green stock returns, with green assets (GA) serving as a moderating variable. This design facilitates the identification and quantification of causal relationships through inferential statistical analysis (Creswell, 2018).

The independent variables consist of the BI 7-Day Reverse Repo Rate (policy interest rate), Consumer Price Index (CPI) growth (inflation), and the average quarterly exchange rate of the Indonesian rupiah (IDR) against the U.S. dollar (USD). The dependent variable, green stock return, is represented by firms listed in the ESG Quality 45 (ESGQ45) and SRI-KEHATI indices, which reflect strong environmental, social, and governance (ESG) performance. The moderating variable—green assets (GA)—is measured by the combined market capitalization of green equities and the total issuance value of green sukuk, representing the depth of Indonesia's green finance ecosystem in absorbing macroeconomic shocks.

This framework integrates macroeconomic fundamentals with sustainability dimensions to assess how green assets—often associated with a "greenium" or sustainability premium (Baker et al., 2018; Zerbib, 2019)—enhance market resilience amid macroeconomic fluctuations (Chen et al., 1986; Fama and French, 2015).

3.2. Population and Sample

The study population includes all firms listed in the ESG Quality 45 (ESGQ45) Index between 2021 and 2023. Developed jointly by the Indonesia Stock Exchange (IDX, n.d.) and the Indonesian Biodiversity Foundation (Kehati), the index serves as Indonesia's leading benchmark for sustainable investment, consisting of 45 firms with the highest ESG ratings (Kehati, 2021).

A purposive sampling technique was employed to select firms with complete and consistent financial and market data across the observation period. Selection criteria included data availability, liquidity, and disclosure quality, resulting in 37 firms deemed most suitable for empirical analysis.

3.3. Operational Definitions, Data, and Research Model

3.3.1. Operational definition and variable measurement

3.3.1.1. Green stock return (RS)

Green stock return refers to the realized return from equity investments in firms classified as green or sustainability-oriented, reflecting both environmental performance and investors' preference for sustainable assets (Pástor et al., 2022). It is computed as the average monthly return of green stocks using the following formula:

$$RS_{i,t} = (P_{i,t}-P_{i,t-1})/P_{i,t-1}$$

Where $P_{i,t}$ and $P_{i,t-1}$ denote the closing stock prices at time t and t-1, respectively. This measure captures the stock's performance and sensitivity to macroeconomic fluctuations.

3.3.1.2. Interest rate (IR)

The interest rate, a key monetary policy indicator, represents the cost of capital and serves as a benchmark for investment and consumption decisions (Mishkin, 2011). It is proxied by the monthly average of the Bank Indonesia 7-Day Reverse Repo Rate (BI7DRR) (Bank Indonesia, n.d.).

3.3.1.3. Inflation (INF)

Inflation is defined as a persistent increase in the general price level, indicating shifts in monetary conditions that affect purchasing power and asset valuation (Fisher, 1930). It is measured using the monthly inflation rate derived from the Consumer Price Index (CPI), as reported by Bank Indonesia (BI) (Bank Indonesia, n.d.) and Statistics Indonesia (BPS).

3.3.1.4. Exchange rate (EXR)

The exchange rate reflects the relative value of the Indonesian rupiah (IDR) against the U.S. dollar (USD). Following Dornbusch (1976) overshooting model, exchange rate fluctuations influence investment costs and expected returns. This study employs the monthly average of the middle exchange rate published by Bank Indonesia.

3.3.1.5. Green assets (GA)

Green assets encompass financial instruments with positive environmental attributes that attract sustainability-oriented investors and may generate a "greenium" in capital markets (Zerbib, 2019). The green asset variable is calculated as the total market value of green equities combined with the outstanding value of green sukuk during the observation period:

$$GA_t = (P_{i,t} \times Q_{i,t}) + \text{Outstanding Green Sukuk}_{i,t}$$

where $P_{i,t}$ represents the price of green stock i, $Q_{i,t}$ denotes the number of outstanding shares, and the second term indicates the total value of green sukuk issued in year *t*. This variable reflects each firm's total exposure to sustainable financial instruments, integrating both equity and debt dimensions of green finance (Flammer, 2021; Kong et al., 2023).

3.3.2. Research data

The study uses secondary data from verified institutional sources. The interest rate, inflation, and exchange rate data are obtained from Bank Indonesia, while green stock prices are collected from the Indonesia Stock Exchange (IDX, n.d.). Data on green sukuk are sourced from the Directorate General of Budget Financing and Risk Management (DJPPR) under the Ministry of Finance, which provides official records on outstanding government and corporate green sukuk.

3.3.3. Research model and estimation method

To assess both direct and moderating effects, this study applies Moderated Regression Analysis (MRA)—a method suitable for testing conditional relationships within a single estimation framework (Hayes, 2018).

The regression equation is formulated as follows:

$$RS_{i,t} = \alpha + \beta_1 IR_t + \beta_2 INF_t + \beta_3 EXR_t + \beta_4 GA_{i,t} + \beta_5(IR_t \times GA_{i,t}) + \beta_6(INF_t \times GA_{i,t}) + \beta_7(EXR_t \times GA_{i,t}) + \varepsilon_{i,t} \quad (1)$$

Where:
$RS_{i,t}$ = Green stock return of firm i in year t
IR_t = Interest rate (BI7DRR) in year t
INF_t = Inflation rate in year t
EXR_t = Exchange rate of the rupiah against the

U.S. dollar in year t
$GA_{i,t}$ = Green assets of firm i in year t
$\varepsilon_{i,t}$ = Error term.

To ensure robustness, the estimation employs heteroskedasticity-robust standard errors, mitigating potential violations of homoskedasticity assumptions (Hayes, 2018). This analytical approach aligns with prior studies examining the stabilizing function of green financial instruments amid macroeconomic volatility (Reboredo, 2018; Pham et al., 2020).

This framework provides a rigorous empirical foundation for testing hypotheses H1–H6 and for explaining how macroeconomic risk factors interact with sustainability-oriented mechanisms in Indonesia's capital market.

4. RESULTS AND DISCUSSION

4.1. Statistical Analysis Results

Table 1 summarizes the descriptive statistics of the study variables, illustrating the behavior of green stock performance under different macroeconomic and sustainability conditions.

The average green stock return of 8.68% with a standard deviation of 1.60% suggests moderate volatility. Both the interest rate (mean = 4.24) and inflation (mean = 4.12) remained relatively stable during the observation period, reflecting effective post-pandemic monetary management in Indonesia. In contrast, the exchange rate recorded the highest variability (SD = 3.10), indicating that external pressures—particularly currency movements—were major sources of market fluctuations.

Table 2 reports the correlation matrix for all study variables, revealing statistically significant relationships that align well with theoretical expectations.

Table 1: Descriptive statistics

Variable	Mean	Standard deviation	Min	Max	n
Stock Return (RS)	8.68	1.60	5.58	10.94	111
Interest Rate (IR)	4.24	1.21	3.20	5.30	111
Inflation (INF)	4.12	1.11	3.21	5.01	111
Exchange Rate (EXR)	5.95	3.10	3.70	9.50	111
Green Assets (GA)	4.25	1.30	3.20	5.32	111
IR×GA	6.75	2.69	5.30	10.41	111
INF×GA	5.48	1.60	4.50	9.01	111
EXR×GA	6.51	2.20	5.53	10.10	111

Source: Authors' computation

The negative correlations between green stock returns and both interest rates ($r = -0.32$, $P < 0.01$) and inflation ($r = -0.35$, $P < 0.01$) suggest that rising borrowing costs and price pressures dampen green equity performance, in line with the Fisher Effect (Fisher, 1930) and the Arbitrage Pricing Theory (Ross, 1976). In contrast, the positive association between green assets and stock returns ($r = 0.31$, $P < 0.05$) aligns with the Green Premium Hypothesis (Zerbib, 2019), indicating that sustainability-linked instruments contribute to portfolio enhancement and long-term market resilience.

Table 3 reports the results of the moderated regression analysis (MRA), which examines both the direct and interaction effects of macroeconomic variables and green assets on green stock returns.

The R^2 value of 0.42 suggests that the model accounts for roughly 42% of the variation in green stock returns. Moreover, the F-statistic is significant at the 1% level, validating the overall robustness and reliability of the regression model.

Figure 1 illustrates the coefficient plot of the estimated regression model, showing each variable's coefficient together with its 95% confidence interval. This visualization clarifies the direction and statistical significance of macroeconomic and sustainability factors influencing green stock returns. Variables marked in green represent statistically significant effects ($p < 0.10$), confirming consistent relationships among interest rates, inflation, green assets, and overall market performance.

Figure 2 depicts the interaction effects between green assets (GA) and the macroeconomic variables—interest rate, inflation, and exchange rate—along with their 95% confidence intervals. The results provide clear visual evidence that the GA × INF interaction is positive and statistically significant, suggesting that the contribution of green assets to stock returns strengthens under inflationary conditions. In contrast, the GA × IR and GA × EXR interactions are statistically insignificant, implying that green assets have not yet effectively mitigated the adverse effects of interest rate fluctuations or exchange rate volatility on green stock performance.

The descriptive statistics confirm that the dataset used in this study is stable and sufficiently representative for analyzing how green stock returns respond to macroeconomic and sustainability-related variables. The mean stock return of 8.68%, with a standard deviation of 1.60%, indicates moderate volatility, suggesting that the sample period reflects normal market dynamics. Meanwhile,

Table 2: Correlation matrix

Variable	RS	IR	INF	EXR	GA	X1_Z	X2_Z	X3_Z
Stock Return (RS)	1.00	−0.32***	−0.35***	−0.27**	0.31**	−0.47***	0.45	0.35**
Interest Rate (IR)		1.00	0.56***	0.21	0.41	0.56***	0.47***	0.50***
INF Inflation (INF)			1.00	−0.05	0.23	0.33	0.47***	0.13
Exchange Rate (EXR)				1.00	0.31	0.25**	0.01	0.33***
GA (Z)					1.00	0.04	0.02	0.06
X1_Z (IR×Z)						1.00	0.03	0.06
X2_Z (INF×Z)							1.00	0.03
X3_Z (EXR×Z)								1.00

Source: Authors' computation

Table 3: Regression results

Variable	Coefficient	t-Statistik	P-value	Conclusion
Constant	8.68	1.16	0.25	Not significant
Interest Rate (IR)	−1.42	−1.72	0.08	H_1 is accepted marginally.
Inflation (INF)	−1.45	−2.83	0.01	H_1 is accepted
Exchange Rate (EXR)	−0.22	−0.70	0.49	Not significant
Green Asset (GA)	1.01	2.01	0.05	Signifikan pada α=5%
IR×GA	−0.36	−1.28	0.21	Not significant
INF×GA	0.90	2.37	0.02	Significant at α=5%
EXR×GA	0.10	1.17	0.25	Not significant
R^2	0.42			The model explains 42% of the variation in stock returns
Adjusted R^2	0.39			After adjustment, the model explains 39% of the data variation
F-statistic	8.23			The model is simultaneously significant at α=1%
Prob (F-statistic)	0.00			The regression model is deemed appropriate (significant at the 1% level).

Source: Authors' computation

Figure 1: Coefficient plot of regression estimates

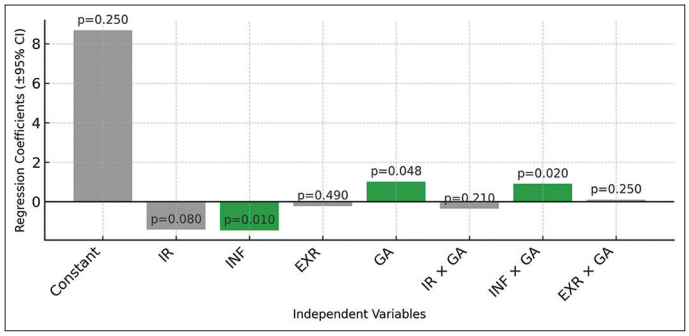
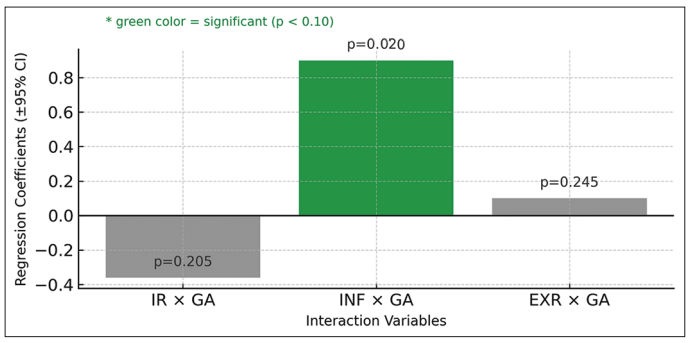


Figure 2: Interaction Plot: GA × IR, GA × INF, GA × EXR



the interest rate (mean = 4.24%) and inflation rate (mean = 4.12%) remained relatively stable, demonstrating effective monetary policy management during the post-pandemic recovery phase. In contrast, the exchange rate exhibits the highest variation (SD = 3.10%), highlighting greater exposure to external macro-financial shocks and global currency fluctuations that influence investor sentiment and capital flows.

The correlation analysis provides preliminary evidence consistent with theoretical expectations. Green stock returns are negatively correlated with both interest rates ($r = -0.32$; $P < 0.01$) and inflation ($r = -0.35$; $P < 0.01$), consistent with the Fisher Effect (Fisher, 1930) and the Arbitrage Pricing Theory (Ross, 1976), which suggest that higher interest rates and inflationary pressures lower asset attractiveness by raising discount rates and reducing real returns. Conversely, the positive relationship between green assets and stock returns ($r = 0.31$; $P < 0.05$) supports the Green Premium Hypothesis Zerbib (2019), implying that sustainability-oriented firms benefit from investor confidence, reduced perceived risk, and enhanced long-term valuation due to superior environmental and governance performance.

The moderated regression analysis (MRA) further validates these correlations and demonstrates consistency with established asset pricing frameworks. The model explains 42% of the variation in green stock returns ($R^2 = 0.42$; $F = 8.23$; $P < 0.01$), underscoring the importance of integrating sustainability factors into macroeconomic asset pricing. Both interest rates ($\beta = -1.42$; $P = 0.08$) and inflation ($\beta = -1.45$; $P = 0.01$) exert downward pressure on green stock performance, confirming that rising financing costs and declining purchasing power weaken real investment returns. In contrast, green assets have a positive and statistically significant effect ($\beta = 1.01$; $P = 0.05$), reinforcing their function as nontraditional financial drivers that enhance resilience and foster long-term value creation. Figure 1 illustrates these results, showing that the coefficients for green assets (GA) and the interaction term (INF × GA) remain significantly positive within the 95% confidence interval.

The interaction analysis presented in Figure 2 further reveals that the moderating role of green assets is most effective under inflationary conditions, as evidenced by the significant positive coefficient of INF × GA ($P = 0.020$). This finding suggests that sustainability-linked instruments can act as an inflation hedge, helping to preserve portfolio value amid rising price pressures. Conversely, the insignificant interactions of IR × GA and EXR × GA imply that Indonesia's green finance market has yet to reach sufficient structural maturity to offset risks arising from monetary tightening or currency volatility. Overall, these results reinforce the complementary roles of the Fisher Effect, the Arbitrage Pricing Theory, and the Green Premium Hypothesis in explaining green stock behavior. Sustainability thus emerges not only as an ethical principle but also as a key determinant of financial stability and market resilience in Indonesia's transition toward a low-carbon economy.

These insights provide valuable implications for policymakers in fostering sustainable financial ecosystems that buffer green markets against macroeconomic uncertainty. The regression model demonstrates a good fit and statistical soundness, further supporting the robustness of the empirical results presented in this study.

4.2. Discussion

The empirical results indicate that green stock performance is influenced not only by macroeconomic fundamentals—such as interest rates, inflation, and exchange rates—but also by sustainability-related financial factors that reflect the depth and structure of the green finance ecosystem. These findings validate the multifactor approach within the Arbitrage Pricing Theory (APT) (Ross, 1976), which suggests that asset returns are shaped by multiple sources of systematic risk. Integrating both macroeconomic and sustainability dimensions offer a more holistic understanding of return behavior in the context of global efforts toward a green economic transition.

A key insight from this study is that interest rates have a negative and statistically significant impact on green stock returns. This is consistent with APT's premise that interest rates determine discount rates and capital costs. Higher borrowing costs and tighter monetary conditions reduce the present value of future earnings, leading investors to reallocate capital away from long-horizon, riskier projects—such as renewable energy ventures. Because these industries are capital-intensive, monetary tightening can decelerate decarbonization and renewable deployment (Aquila and Wullweber, 2024). These results underscore the need for coordinated monetary and sustainability policies to ensure that financial stability and environmental investment objectives are mutually supportive.

Inflation is also shown to negatively and significantly affect green stock performance, consistent with the Fisher Effect (Fisher, 1930), which states that higher inflation diminishes real investment returns unless compensated by nominal adjustments. Within the APT framework, inflation functions as a systematic risk factor that raises required returns, disrupts cost structures, and increases valuation uncertainty. For sustainability-oriented firms, higher input and technology costs heighten operational pressures, particularly in sectors undergoing energy transition. This result reflects emerging patterns of "fossilflation" and "greenflation," driven respectively by fossil fuel price volatility and transitional costs of adopting cleaner energy systems (Aquila and Wullweber, 2024).

Extending this interpretation, inflation's adverse effect demonstrates how price instability constrains sustainable investment in developing economies. Persistent inflation raises production costs, narrows profit margins, and dampens capital flows toward long-term environmental projects. Addressing this issue requires integrated green macroeconomic strategies—such as energy diversification, technology subsidies, and targeted fiscal measures—to manage structural inflation risks while sustaining clean energy investment. This reconceptualization broadens the traditional Fisher framework by positioning inflation as both a monetary and environmental challenge, shaped by transition-related factors in a low-carbon economy.

In contrast, exchange rate fluctuations are found to exert no significant effect on green stock returns. While exchange rate movements remain an established APT risk factor—especially for import-dependent or export-oriented firms—the insignificant result suggests that Indonesian green firms may have developed adaptive mechanisms, such as hedging or operational realignment, to mitigate currency volatility. Prior evidence supports this interpretation, showing that financial hedging tools and risk management strategies can substantially reduce exposure to exchange rate uncertainty (Bartram and Bodnar, 2007). Consequently, exchange rate sensitivity appears contingent upon sectoral characteristics, market integration, and firm-level resilience.

Distinct from conventional macroeconomic drivers, green assets exert a positive and statistically significant effect on green stock returns. This supports the Green Premium Hypothesis (Zerbib, 2019), which proposes that investors are willing to accept lower returns for sustainability-oriented investments due to reduced long-term risk and enhanced governance. Green financing mechanisms also improve technological innovation, energy efficiency, and firm competitiveness (Zhang et al., 2022). Furthermore, empirical evidence suggests that green assets lower tail-risk exposure, improve portfolio efficiency, and enhance market resilience during financial shocks (Akhtaruzzaman et al., 2023; Ramlall, 2024). These results affirm that sustainability has evolved from an ethical concept into a strategic determinant of financial stability and value creation.

The moderating analysis reveals that the interaction between inflation and green assets (INF × GA) is positive and statistically significant, indicating that green assets act as an effective hedge against inflationary pressures. During inflationary periods, investors perceive sustainability-linked instruments as safe-haven assets that preserve real value and provide portfolio stability. This is consistent with findings from international markets where green bonds and other ESG-linked products have demonstrated resilience during inflationary and supply chain disruptions (Kong et al., 2023). However, the insignificant moderating effects of interest rates (IR × GA) and exchange rates (EXR × GA) imply that Indonesia's green finance ecosystem is still developing and lacks sufficient liquidity depth to offset monetary tightening or currency fluctuations (Aquila and Wullweber, 2024).

Overall, the findings demonstrate a coherent integration of the Arbitrage Pricing Theory (APT), the Fisher Effect, and the Green Premium Hypothesis in explaining green stock behavior. While APT underscores the influence of macroeconomic fundamentals on expected returns, the Fisher Effect clarifies the impact of inflation and monetary policy on real investment outcomes. Complementing these frameworks, the Green Premium Hypothesis positions sustainability as a structural driver of market stability. Collectively, these perspectives affirm that green assets function as stabilizing instruments—particularly during inflationary periods—thereby strengthening capital market resilience amid the global transition toward a low-carbon economy.

The findings offer important implications for both investors and policymakers. For investors, integrating green assets into portfolios enhances diversification and risk–return efficiency while providing a natural hedge against inflation and systemic shocks. For policymakers, broadening access to green finance and improving market infrastructure are critical to accelerating the clean energy transition and mobilizing private capital for

sustainable projects. Regulatory measures—such as green bonds, tax incentives, and blended finance—can strengthen liquidity and lower financing barriers in renewable sectors. Theoretically, this study advances the sustainable finance literature by showing that sustainability-linked instruments are increasingly embedded in modern asset pricing. Overall, the results confirm that green finance reinforces market resilience and strengthens the structural stability of financial systems during the global shift toward a climate-aligned economy.

4.3. Robustness Check

To verify the reliability of the empirical results, the regression model was re-specified and re-estimated using one-period lagged macroeconomic variables—interest rate (IR), inflation (INF), and exchange rate (EXR). This specification reduces potential short-term reverse causality and captures delayed monetary and external shocks, which are common in emerging markets due to structural rigidities and information asymmetry. The approach is consistent with the Efficient Market Hypothesis (Fama, 1970), which posits that asset prices incorporate past information, and aligns with the Arbitrage Pricing Theory (Ross, 1976), emphasizing the central role of macroeconomic factors in return dynamics.

The moderating role of green assets (GA) was further examined through Moderated Regression Analysis (MRA) applied to the lagged variables, as specified in the following equation:

$$RS_{it} = \alpha + \beta_1 IR_{t-1} + \beta_2 INF_{t-1} + \beta_3 EXR_{t-1} + \beta_4 Z_{t-1} + \beta_5 (IR_{t-1} \times Z_{t-1}) + \beta_6 (INF_{t-1} \times Z_{t-1}) + \beta_7 (EXR_{t-1} \times Z_{t-1}) + \varepsilon_{it} \quad (2)$$

Where:
RS_{it}: Excess return of portfolio i in year t
IR_{t-1}: Interest rate in the previous year (lag 1)
INF_{t-1}: Inflation rate in the previous year (lag1)
EXR_{t-1}: Exchange rate in the previous year (lag1)
Z_{t-1}: Green assets in the previous year (lag1)
ε_{it}: Error term.

Table 4 compares the baseline and lagged regression models, confirming the robustness of the estimated results. The consistency in coefficient direction, significance, and explanatory power across both models indicates that the relationships remain stable even after accounting for lagged macroeconomic effects and sustainability exposures. These results reaffirm that interest rates and inflation are the primary macroeconomic determinants of green stock performance, while green assets strengthen market stability, particularly under inflationary conditions. Conversely, the exchange rate exerts only a minor and statistically insignificant influence, suggesting that green stocks are relatively insulated from currency fluctuations within Indonesia's financial system.

The one-period lag model further substantiates these findings. The persistence of coefficient patterns and the stable explanatory power (Adj. $R^2 \approx 0.39$) confirm that the results are not sensitive to delayed macroeconomic shocks. Interest rates (IR) remain negatively associated with green stock returns, inflation (INF) continues to exert a significant negative impact, and green assets (GA) consistently enhance market performance. The interaction term between inflation and green assets (INF × GA) remains positive and significant, highlighting their role in mitigating inflationary pressures. In contrast, the interaction terms involving interest rates and exchange rates (IR × GA and EXR × GA) remain insignificant, implying that Indonesia's green financial instruments have yet to develop sufficient depth to hedge effectively against monetary tightening or currency volatility.

Overall, the robustness analysis confirms the internal consistency and empirical validity of the model. Inflation and green assets emerge as key drivers of green stock performance, while exchange rate effects remain marginal—reflecting a gradually maturing yet resilient structure of Indonesia's green financial ecosystem.

5. CONCLUSION

This study demonstrates that both macroeconomic fundamentals and sustainability-oriented financial factors significantly influence green stock returns in Indonesia. Interest rates and inflation exert negative effects by raising the cost of capital and lowering real investment returns, whereas green assets enhance market performance by strengthening portfolio resilience and mitigating inflation-induced risks. These findings empirically validate the complementary relevance of the Arbitrage Pricing Theory (APT), the Fisher Effect, and the Green Premium Hypothesis, providing a comprehensive understanding of how systematic risks and sustainability attributes jointly shape asset pricing dynamics during the transition toward a low-carbon economy. The integration of these theoretical perspectives confirms that sustainability-linked variables are not peripheral considerations but fundamental determinants of market behavior in emerging green financial systems.

Table 4: Robustness check: baseline model vs. lagged model

Variable	Baseline Model Coefficient (t-stat)	p-value	Lagged Model (t–1) Coefficient (t-stat)	p-value
Constant	8.68 (1.16)	0.25	8.41 (1.09)	0.28
IR	–1.42 (–1.72)	0.08	–1.37 (–1.65)	0.10
INF	–1.45 (–2.83)	0.01	–1.39 (–2.71)	0.01
EXR	–0.22 (–0.70)	0.49	–0.19 (–0.62)	0.54
GA	1.01 (2.01)	0.05	0.98 (1.94)	0.06
IR×GA	–0.36 (–1.28)	0.21	–0.34 (–1.21)	0.23
INF×GA	0.90 (2.37)	0.02	0.87 (2.29)	0.02
EXR×GA	0.10 (1.17)	0.25	0.09 (1.11)	0.27
R^2	0.42	—	0.41	—
Adjusted R^2	0.39	—	0.39	—
F-statistic	8.23	0.00	7.94	0.00

From a theoretical standpoint, this research enriches the literature on sustainable finance and energy economics by identifying green assets as key stabilizing mechanisms within financial markets. The evidence suggests that sustainability has evolved from an ethical preference into a core strategic element for mitigating macroeconomic vulnerabilities and enhancing long-term investment resilience. Practically, the findings highlight the need for investors to integrate green assets into portfolio diversification and inflation-hedging strategies, while policymakers should strengthen and deepen green financial markets to channel capital toward renewable energy investments and preserve macroeconomic stability. Despite these contributions, the study acknowledges certain limitations, including the relatively short observation period and reliance on secondary data, which may be affected by reporting frequency and measurement accuracy. Future research should extend the time horizon, employ firm-level panel data with broader sustainability indicators, and incorporate exogenous shocks—such as geopolitical risks, financial crises, or climate policy shifts—to enhance the robustness and generalizability of the findings under varying economic conditions.

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