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Sustainable invesment challenges in emerging markets: Case of India's NIFTY100ESG indices

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ABSTRACT

The NIFTY100 ESG Indices in India are influenced by macroeconomic factors such as currency exchange rates, economic policy uncertainty (EPU), CBOE VIX, and global commodity prices like gold and crude oil. Despite the increasing relevance of sustainable investing, limited research has explored how these factors impact ESG-focused indices in emerging markets. This study examines their short- and long-term effects using the Autoregressive Distributed Lag (ARDL) model, analyzing monthly data from January 2019 to December 2024. The findings indicate that in the short term, CBOE VIX, exchange rates, and gold prices negatively affect the index, while gold prices have a positive impact in the long run. Meanwhile, exchange rates, EPU, and crude oil prices show no significant influence. By specifically focusing on India's ESG investments, this research fills a crucial gap in the literature, moving beyond conventional stock market studies. The results emphasize the importance of strong economic policies and risk management strategies to enhance market stability and promote sustainable investments, offering valuable insights for investors, policymakers, and regulators in an evolving financial landscape.

1. Introduction

Sustainable investment integrates environmental, social, and governance (ESG) factors into financial decision-making, aiming to achieve both financial returns and long-term sustainability. According to Jain et al (2019), this investment approach involves selecting assets based on ESG criteria, ensuring that economic benefits align with ethical, social, and environmental considerations. Similarly, Kocmanová et al (2020) highlights that sustainable investment aims to generate positive societal and environmental outcomes while maintaining financial stability and minimizing investment risks. As concerns over climate change, resource depletion, and social inequality continue to grow, investors increasingly adopt sustainability-focused strategies to enhance corporate responsibility and economic resilience. Sustainable investment has rapidly gained global traction in alignment with the United Nations' 2030 Agenda, which addresses significant sustainability challenges through the 17 Sustainable Development Goals (SDGs). Beyond fostering environmental and social responsibility, sustainable investment also contributes to long-term economic stability and growth, leading to positive financial outcomes for investors (Sahoo, 2024).

One of the key drivers of this development is the existence of sustainability indices, which highlight companies adhering to stringent environmental, social, and governance (ESG) standards. These indices guide investors toward portfolios that not only yield returns but also align with broader ethical and sustainability principles (Tolliver et al., 2021). Despite the growing emphasis on sustainable investment, recent data from the Global Sustainable Investment Alliance shows a global

decline in sustainable investment assets from USD 35.3 trillion in 2021 to USD 30.3 trillion. This decrease is partly attributed to shifts in methodology in the U.S. market and heightened concerns about greenwashing and "greenhushing." Greenwashing, which misleads investors by portraying unsustainable products as environmentally friendly, erodes trust and deters investments (Dempere et al., 2024). Meanwhile, greenhushing, where companies obscure their sustainability initiatives to avoid scrutiny, reduces transparency and undermines progress toward sustainable development goals (Dempere et al., 2024).

India represents one of these dynamic emerging markets, projected to rank as the third-largest GDP in Asia by 2024, after China and Japan. India's economy has maintained robust growth, evidenced by the IMF's (2024) estimate of a 7% GDP increase in July 2024. This growth has propelled the country's sustainable investment landscape, exemplified by the NIFTY100ESG indices. The indices comprises companies from the Nifty 100 with strong ESG scores and excludes entities involved in controversial or vice industries (e.g., tobacco, alcohol, gambling). Weightings are determined by free-float market capitalization adjusted by ESG scores and recalibrated semi-annually. In terms of sector representation, financial services (31.48%) and information technology (20.54%) hold the largest shares, making the indices an essential benchmark for sustainable investments such as exchange-traded funds (ETFs). Investors increasingly rely on sustainability indices as critical tools for building socially responsible portfolios (de Oliveira et al., 2020). Among these, the NIFTY100ESG indices has demonstrated strong performance, offering superior resilience and adaptability compared to traditional benchmarks (Nain et al., 2023). However, despite the growing global focus on sustainability, studies specifically examining the NIFTY100ESG indices remain limited (Vadithala & Tadoori, 2021). This presents a notable research gap, as India, a rapidly expanding economy with significant emphasis on sustainable finance, has yet to be fully explored in terms of how various macroeconomic variables such as exchange rates, Economic Policy Uncertainty (EPU), the CBOE VIX, and commodity prices (e.g., gold and oil) impact the performance of this indices.

The existing literature offers varying perspectives on the effects of these macroeconomic factors. Among these, exchange rate fluctuations, economic policy uncertainty (EPU), market volatility (CBOE VIX), and commodity prices (gold and oil) have emerged as key determinants influencing ESG-focused indices. While prior studies have explored the impact of these variables on broader market indices, research specifically on the NIFTY100ESG indices remains limited. However, given the sensitivity of related indices such as the NSE Nifty large-cap 100, Nifty mid-cap 100, and Nifty small-cap to these macroeconomic conditions (Mohanty et al., 2023), it is reasonable to anticipate that sustainability-focused investments are also subject to similar influences. Exchange rate volatility is one of the key macroeconomic factors influencing market stability and investment decisions, particularly in developing economies. A stable exchange rate contributes to economic confidence, supporting long-term investment strategies and sustainable growth (Chikwira & Jahed, 2024). While currency depreciation can boost export competitiveness, it also raises import costs and inflation, which may create challenges for sustainable investments (Liao et al., 2019). Moreover, fluctuations in exchange rates impact foreign direct investment (FDI), as greater stability lowers the risks associated with currency fluctuations, making sustainable investment opportunities more appealing. However, research on markets such as India suggests that exchange rate movements have minimal influence on stock market returns, implying that domestic market factors may help mitigate the effects of currency volatility (Chellaswamy et al., 2020).

Economic Policy Uncertainty (EPU) is another key factor that affects investment decisions, as it represents the risks linked to unpredictable government policies and regulatory shifts. A rise in EPU discourages long-term investments, as businesses and investors tend to postpone spending due to uncertainty, leading to reduced capital formation and economic slowdown (Al-Thaqeb & Algharabali, 2019). Additionally, heightened policy uncertainty increases risk premiums, making borrowing more expensive and weakening overall market confidence (Guo et al., 2020). While some research suggests that firms may improve their ESG performance as a means of mitigating risks during uncertain periods (Wu et al., 2024), other studies emphasize that prolonged uncertainty hampers innovation and sustainability focused investments due to the absence of stable regulatory incentives (Farooq et al., 2024). As a result, EPU has a dual impact, influencing both financial markets and ESG investment strategies by shaping corporate decision-making and investor confidence.

Market volatility, represented by the CBOE VIX, adds another layer of complexity to the relationship between sustainability and investment. Commonly known as the 'fear gauge,' the VIX reflects market uncertainty, which directly impacts investor sentiment and the flow of funds into ESG

investments (Shaikh, 2020). A rising VIX indicates increased risk aversion, often leading to capital withdrawals from equities, including sustainable assets. As a measure of expected short-term volatility derived from S&P 500 index option prices, the VIX serves as a key tool for evaluating investment risks (Daniali et al., 2021). However, sustainable investments have demonstrated relative resilience during volatile periods, as investors increasingly perceive them as stable long-term assets (Wei et al., 2024). This highlights the necessity of incorporating market risk assessments into sustainable investment strategies to minimize negative spillover effects and enhance portfolio stability.

Beyond policy and market volatility, commodity prices, particularly gold and oil, play a crucial role in shaping sustainable investment performance. Gold, a safe-haven asset, often moves inversely with ESG stocks as investors hedge against inflation during uncertainty (Shabbir et al., 2020). In India, one of the largest gold consumers, its cultural and financial significance reinforces its role as an inflation hedge, with studies showing a long-term equilibrium between gold prices and CPI (Singh & Joshi, 2019). Demand remains inelastic to price changes, as cultural and security factors outweigh cost concerns (Immanuvel & Lazar, 2021). To promote sustainable investment, India's gold monetization schemes aim to integrate idle gold into the financial system, reducing import reliance and encouraging its use as a financial asset**.** Meanwhile, oil price fluctuations impact sustainability-driven investments, especially in oil-importing nations like India. Higher oil prices drive inflation and affect stock markets but also boost renewable energy's appeal by making alternatives more competitive (Serap Vurur et al., 2024). WTI oil prices are particularly relevant to sustainable investment, as financial stress and volatility measured by the VIX tend to suppress them over time (Le et al., 2021). Given their influence on inflation, energy costs, and investment flows, WTI oil price fluctuations shape both traditional and sustainable markets. These gold-oil dynamics underscore the need to understand commodity prices when assessing ESG performance.

Despite the well-established link between macroeconomic factors, commodity prices, and financial markets, research examining their effects on sustainable investments in India, as represented by the NIFTY100ESG indices, remains limited. While Darsono et al (2022) analyzed Economic Policy Uncertainty (EPU) and commodity prices in a panel of 12 countries, including India, their study did not isolate the specific market dynamics affecting NIFTY100ESG. Similarly, prior studies have employed the ARDL model to assess macroeconomic influences on broader Indian indices, such as Nifty200 (Kuntamalla & Maguluri, 2022), or sector-specific indices like the Nifty Auto Index (Alexander & Al-Malkawi, 2023), yet none have focused on the interplay between EPU, CBOE VIX, exchange rates, and commodity prices in shaping the performance of India's primary ESG benchmark. Addressing this gap, this study employs the ARDL approach with monthly data from January 2019 to December 2024 to analyze both short- and long-term effects of these variables on the NIFTY100ESG indices. By offering a country-specific perspective, this research provides valuable insights for policymakers and investors to strengthen ESG portfolio resilience and refine sustainable investment strategies in India.

2. Literature Review

Sustainable investment is an investment approach that considers environmental, social, and governance (ESG) factors in financial decision-making. The goal is to create long-term value for investors while generating positive impacts on society and the environment. This approach has gained prominence as awareness of sustainability in economic and investment activities continues to grow. One of the primary theories supporting sustainable investment is the Triple Bottom Line (TBL) concept, introduced by John Elkington in 1997. This model emphasizes the integration of financial performance with social and environmental considerations. TBL evaluates companies based on three key aspects: planet, people, and profit, encouraging businesses to adopt sustainable strategies. The concept asserts that long-term business success should be evaluated not only based on financial performance but also on its positive impact on society and the environment. By implementing TBL, companies not only generate long-term value for shareholders but also benefit society and the environment. For investors, TBL serves as a framework to identify companies that balance sustainability with profitability while aligning their operations with the Sustainable Development Goals (SDGs) (Khan, 2024).

While the TBL framework provides a foundation for assessing sustainable investments, external macroeconomic factors also play a crucial role in shaping their performance. Exchange rate fluctuations play a critical role in shaping sustainable investment decisions, influencing investor

confidence, capital flows, and economic stability. Mroua & Trabelsi (2020) found that exchange rate movements affect stock returns in BRICS countries, while Darsono et al (2023) observed a negative impact on sustainable stock markets in Asia during the COVID-19 pandemic, as currency depreciation led to capital outflows and reduced investor confidence. Similarly, Javangwe & Takawira (2022), using ARDL modeling, found that exchange rate volatility weakens stock market performance in emerging economies, particularly during financial instability when depreciation increases market uncertainty and discourages long-term investment. However, some studies suggest that the long-term impact of exchange rate fluctuations is less pronounced, as firms and investors adapt through hedging strategies and policy interventions (Atri et al., 2023; Tran & Vo, 2023). Chikwira & Jahed (2024) highlights that exchange rate stability fosters economic growth by creating a predictable environment for trade and investment, attracting Foreign Direct Investment (FDI), and reducing inflationary pressures, whereas excessive volatility raises import costs, fuels inflation, and increases operational risks for sustainable investments. Based on these insights, this study hypothesizes that exchange rate fluctuations negatively affect sustainable indices or otherwise, depending on market conditions and policy responses.

Economic Policy Uncertainty (EPU), alongside exchange rate volatility, is a key macroeconomic factor shaping sustainable stock indices, influencing investor sentiment and capital allocation. Research shows EPU's impact varies across markets and timeframes. Durmaz (2024) found a negative short-term impact on stock markets in Belgium and Singapore, as policy uncertainty drives cautious investment behavior. Meanwhile, Darsono et al (2022) reported significant long-term effects on sustainable stocks globally, suggesting persistent uncertainty shapes corporate risk management and investment decisions. In Indonesia, Darsono et al (2024) found EPU positively influenced the SRI-KEHATI indices in the long run, though its short-term impact was insignificant, indicating investors adjust to policy risks over time. Similarly, Bagh et al (2023) found EPU had a significant long-term positive effect on China's stock prices, despite weaker short-term interactions, reinforcing EPU's role in increasing market volatility. Their study also highlighted bidirectional causality between EPU and stock prices, meaning market movements can also shape policy uncertainty. However, Guo et al (2020) found that while EPU has a weak long-term positive association with stock market performance, the effect is statistically insignificant, suggesting investors adapt over time, reducing its disruptive impact. These findings highlight regional and structural differences in EPU's influence, shaped by regulatory frameworks, investor behavior, and economic resilience. Thus, this study hypothesizes that EPU fluctuations negatively impact sustainable indices in the short run but may have a weak or insignificant positive effect in the long run as markets adjust.

Building on this understanding of macroeconomic influences, market volatility measured by the CBOE VIX emerges as another key determinant of sustainable investment performance. Research consistently shows that rising VIX levels increase market uncertainty and negatively affect sustainable investments. Elevated VIX levels significantly reduce sustainable stock performance in the short and long term, especially in emerging economies (de Oliveira et al., 2020; Nittayakamolphun et al., 2024; Tran & Vo, 2023). These findings highlight that persistent volatility undermines sustainable investment growth, with the VIX serving as a reliable predictor of negative market movements. Similarly, Daniali et al (2021) confirmed that rising VIX levels lead to substantial short-term declines in stock returns, reinforcing its role as a risk indicator. However, the impact of VIX is not entirely uniform. Naeem et al (2023) observed that while VIX can enhance market efficiency during upturns, it negatively affects performance during downturns, suggesting that volatility can both signal growth opportunities and amplify investment risks. Beyond investment decisions, VIX trends offer valuable insights for policymakers, aiding in the development of early warning systems and policies that support sustainable investment resilience. Overall, these findings underscore that the VIX amplifies uncertainty, particularly during bearish and volatile periods, making it a crucial variable for sustainability-focused investors. Thus, this study hypothesizes that rising VIX levels negatively affect sustainable indices in both the short and long term, with stronger impacts during periods of heightened market volatility.

Commodity prices, particularly gold and WTI oil prices, play a significant role in shaping sustainable stock market performance. Gold prices often serve as a hedge against inflation and economic instability, though their effects on sustainable indices vary across markets. Darsono et al (2022) identified a positive long-term relationship between gold prices and sustainable stock returns globally, while Singhal et al (2019) found a similar positive impact in Mexico, reinforcing gold's role as a value-preserving asset. However, Darsono et al (2024) reported that gold prices negatively

affected Indonesia's sustainable stocks, indicating that in some markets, rising gold prices may divert capital away from equities. This inverse relationship is supported by Atri et al (2023), who found that long-term gold price shocks significantly decrease the S&P 500 index, confirming gold's role as a safe-haven asset that competes with stocks. In the short term Atri et al (2023) show that gold price increases drive stock market declines, further demonstrating its negative correlation with equity markets during periods of volatility. Additionally, Shabbir et al. (2020) emphasized gold's importance as an inflation hedge, stabilizing investment portfolios, while Mirza et al (2023) noted that gold price volatility significantly impacts sustainable investment interdependence, especially during economic crises like COVID-19. Thus, this study hypothesizes that gold prices have a negative short-term impact on sustainable indices due to their safe-haven role but may have a positive long-term effect as a hedge against inflation and economic instability.

Similarly, WTI oil prices have exhibited both positive and negative effects on sustainable investments, depending on regional energy market structures and economic conditions. Darsono et al (2022) found that rising oil prices positively influence sustainable stock returns globally, while Serap Vurur et al (2024) reported that higher oil prices boost renewable energy investments, suggesting that as oil becomes more expensive, investors shift toward sustainable alternatives. However, Nittayakamolphun et al (2024) found that WTI oil prices negatively impacted Indonesia's sustainable stocks in the long run, highlighting the regional dependence on fossil fuel markets. Supporting this, Atri et al (2023) found that WTI oil prices have a significant positive impact on the S&P 500, reinforcing oil's role in traditional equity markets. Conversely, Le et al (2021) study revealed that global stock market performance positively affects WTI crude oil prices, indicating that strong equity markets drive oil demand and investment in both conventional and renewable energy sectors. Thus, this study hypothesizes that oil prices positively impact sustainable investments in the long run by driving renewable energy investment.

3. Method

This study adopts a quantitative approach, relying on secondary data. The data consists of time-series numerical values, organized from 2019 to 2024. Data is collected monthly during the period January 2019 to December 2024 and analyzed using econometric methods. The data utilized in this study includes the NIFTY100ESG Indices, USD to INR Exchange Rate, Economic Policy Uncertainty (EPU), CBOE VIX, Gold Price, and WTI Oil Price. The NIFTY100ESG Indices data sample was obtained from the official website niftyindices.com. Exchange Rate USD to INR data was obtained from investing.com. India's Economic Policy Uncertainty Indices (EPU) data was obtained from policyuncertainty.com, EPU is an indices based on newspaper coverage frequency that measures the unpredictability of government policies and regulations, impacting economic decisions by businesses and households, leading to lower investment, reduced employment, and slower economic growth (Baker et al., 2016). CBOE VIX data was obtained from fred.stlouisfed.org. Historical gold futures price data was obtained from investing.com, and finally historical WTI Crude Oil futures price data was also obtained from investing.com.

This study employs the Autoregressive Distributed Lag (ARDL) approach to examine the long-term and short-term relationships among the research variables. The ARDL model was selected due to its flexibility in accommodating variables with different levels of integration, specifically when there is a mix of variables that are stationary at level I(0) and those stationary at the first difference I(1) (Pesaran & Shin, 1999). This capability makes ARDL one of the effective methods in analyzing time series data that has heterogeneous properties. However, challenges include sensitivity to lag specification, potential inconclusive bounds test results, and difficulty in handling structural breaks (Pesaran et al., 2001). According to Darsono et al. (2024) the ARDL approach is selected because it accommodates variables that are stationary at different levels, ensuring robust and reliable results for both short- and long-term relationships. This study specifically explores the relationship between the variables NIFTY100ESG (NIFTY100ESG indices) recognized in The National Stock Exchange of India (NSE), EXRATE (Exchange Rate USD/INR), EPU (Indian Economic Policy Uncertainty Indices), CBOEVIX (CBOE Volatility Indices), and GOLD (global gold price) and WTIOIL (world crude oil price). The analysis model is divided into two main parts, namely the short-term model and the long-term model. The following Equation (1) presents the formulation of the long-term model within the ARDL approach, illustrating the equilibrium relationship among the research variables:

$$\ln(NIFTY100ESG_t) = \alpha + \sum_{i=1}^{p} \beta_0 \ln(Exrate_{t-1}) + \sum_{i=1}^{p} \beta_1 \mathrm{EPU}_{t-1}) + \sum_{i=1}^{p} \beta_0 \mathrm{CBOEVIX}_{t-1}) + \sum_{i=1}^{p} \beta_0 \ln(Gold_{t-1}) + \sum_{i=1}^{p} \beta_0 \ln(WTIoil_{t-1}) + \varepsilon_{it} \quad (1)$$

Meanwhile, equation 2 shows the short-term model in the ARDL approach as follows:

$$\Delta \ln(NIFTY100ESG_t) = \alpha + {}_i\begin{pmatrix} NIFTY100ESG_{t-1} - {}_1 Exrate_{t-1} - {}_2 EPU_{t-1} \\ - {}_3 CBOEVIX_{t-1} - {}_4 Gold_{t-1} - {}_5 WTIoil_{t-1} \end{pmatrix} + \sum_{i=1}^{p} \beta_0 \ln(Exrate_{t-1}) + \sum_{i=1}^{q} \beta_1 EPU_{t-1} + \sum_{i=1}^{q} \beta_2 CBOEVIX_{t-1} + \sum_{i=1}^{q} \beta_3 \ln(Gold_{t-1}) + \sum_{i=1}^{q} \beta_4 \ln(WTIoil_{t-1}) + \varepsilon_t \quad (2)$$

The coefficients of each variable indicate the long-term effect of that variable on NIFTY100ESG, while the lags, represented by *p* and *q*, capture the dynamic nature of the relationship over time. In this formula, *t* denotes time, and the error term is represented by ε. Equation (2) outlines the short-term model, which accounts for changes in the variables and the rate of adjustment toward long-term equilibrium through the Error Correction Term (ECM).

4. Results and Discussion

Table 1 shows the statistical description of the research variables includes measures such as mean, median, maximum, standard deviation, and the total number of observations. Each variable in the study has 72 observations, resulting in a total of 432 data points across all variables. The NIFTY100ESG indices averaged 3190.16, with significant fluctuations, reflecting the ever-changing dynamics of sustainability-based investments. The USD to INR exchange rate was relatively stable at an average of 77.39, with moderate variations influenced by global and domestic economic conditions. The Indian Economic Policy Uncertainty Indices (EPU) highlighted a fairly high level of uncertainty, which fluctuated significantly during the period. The CBOE VIX, a global market volatility indicator, averaged 20.35, indicating moderate levels of volatility that remain relevant for investor decisions. Gold prices averaged USD 1864.17 per troy ounce and WTI crude oil prices averaged USD 68.48 per barrel also showed dynamic movements, influenced by various global factors such as monetary policy, geopolitics, and market demand.

Table 1. Descriptive Statistics

Variable	Mean	Max	Min	Std Dev	Obs
NIFTY100ESG	3190.16	5131.68	1765.83	902.37	72
Exrate	77.39	85.55	69.64	4.90	72
EPU	87.35	193.14	23.35	34.84	72
CBOEVIX	20.35	57.74	12.52	7.27	72
Gold	1864.17	2749.30	1285.70	326.81	72
WTIoil	68.48	114.67	18.84	19.04	72

Source: data processed

The initial test conducted in the ARDL panel approach is the unit root test. This test determines the long-term relationship between series with different integration orders, such as level I(0) and first difference I(1). Commonly, the Dickey-Fuller or Augmented Dickey-Fuller (ADF) test is used for this

purpose (Nkoro & Uko, 2016). Table 2 shows that most of the variables in this model are not stationary at the level, with a probability greater than 0.05, but become stationary after the first differentiation. The variables NIFTY100ESG, Exchange Rates, Gold Price, and WTI Oil Price show that the data at the level contains a unit root, but the data becomes stationary after the first level of differentiation, with a probability value of less than 0.05. Meanwhile, the variables EPU and CBOE VIX are already stationary at the level level, meaning they do not require further differentiation. Based on these results, no variables are integrated at an order greater than I(1) to avoid spurious regression (Kurniawan et al., 2023).

Table 2. Stationery Test

Variable	Level		First Diff	
	t-stat	Prob.	t-stat	Prob.
NIFTY100ESG	-0.3048	0.9181	-6.2403	0.0000
Exrate	-0.1987	0.9330	-6.2879	0.0000
EPU	-2.9721	0.0425	-7.7243	0.0000
CBOEVIX	-3.5904	0.0083	-8.4567	0.0000
Gold	-0.1475	0.9394	-8.3942	0.0000
WTIoil	-1.6387	0.4577	-7.5368	0.0000

Source: data processed

The next stage is the cointegration test, which functions to determine the long term between variables (Pesaran & Shin, 1999). In this study, the method used to test cointegration is the Bound Test. Table 3 shows F-statistic value of 5.351, with five independent variables (K = 5), demonstrates a significant relationship among the variables tested in the model. When compared to the critical value bounds, the F-statistic exceeds the upper limit (I(1) Bound) at all significance levels: 10% (3.00), 5% (3.38), 2.5% (3.73), and 1% (4.15). This result leads to the rejection of the null hypothesis, confirming that the relationships among the variables in the model are statistically significant. The F-statistic value, being substantially higher than the critical upper bound, provides strong confidence in the validity of the model's relationships (Kurniawan & A'yun, 2022).

Table 3. Bound Test for Cointegration Test

Test Statistics	Value	K
F-Stat	5.351	5
Critical Value Bounds		
Significance	I (0) Bound	I (1) Bound
10%	2.08	3
5%	2.39	3.38
2.5%	2.7	3.73
1%	3.06	4.15

Source: data processed

Table 4 shows the short-term estimation results reveal that exchange rates have a significant negative impact on the NIFTY100ESG indices, with a coefficient of -2.1373 (p = 0.0040), indicating that a 1% increase in exchange rates leads to a 21.37% decline in the indices. Additionally, the CBOE VIX demonstrates a significant negative effect in both the current period (coefficient -0.0054, p = 0.0000) and at lag 2 (coefficient -0.0004, p = 0.0000), highlighting the sensitivity of ESG indices to global market volatility. Gold prices exhibit a consistent negative relationship across lag 1, lag 2, and lag 3, with coefficients of -0.2918, -0.2413, and -0.3531, respectively, indicating that increases in gold prices in prior periods tend to reduce the NIFTY100ESG indices. The CointEq(-1) coefficient of -0.1009 (p = 0.0000) signifies that approximately 10.09% of deviations from the long-term equilibrium are corrected each period, validating the model's adjustment mechanism. The R-squared value of 0.7689 demonstrates that the model explains 76.89% of the variation in the NIFTY100ESG indices, confirming its suitability for analyzing short-term relationships among the variables.

The exchange rate exerts a significant negative influence on the NIFTY100ESG indices in the short term, indicating that fluctuations in exchange rates can disrupt the stability of India's sustainable stock market, even amidst the relative stability of the USD to INR exchange rate. Minor volatility in exchange rates may increase the cost of international trade and impact the profitability of companies,

particularly those in the financial services sector, which is a key contributor to these indices. This result aligns with the findings of Mroua and Trabelsi (2020), who observed that exchange rates significantly impact stock market indices in emerging markets. However, it contrasts with de Oliveira et al (2020) who found no significant effect of exchange rates on sustainability indices in China, possibly due to differences in market structure or insulation from global volatility. According to Liao et al (2019) exchange rate depreciation can enhance trade terms and boost exports but simultaneously leads to higher import prices and imported inflation. For the NIFTY100ESG indices, the financial services sector plays a pivotal role in ensuring stability, emphasizing the relevance of risk mitigation strategies, such as hedging or diversifying currency portfolios, to minimize the effects of volatility. At a macroeconomic level, these findings highlight the critical role of exchange rate stability in sustaining investor confidence in the sustainable stock market.

Table 4. Result of Short-run ARDL Estimation

ARDL (3, 1, 0, 3, 4, 0) Based on Values od AIC Dependent Variables: NIFTY100ESG		
Variable	Coefficient	Prob.
D (EXRATE)	-2.1337*** (0.7085)	0.0040
D (CBOEVIX)	-0.0054*** (0.0005)	0.0000
D (CBOEVIX (-1))	-0.0021 (0.0007)	0.5199
D (CBOEVIX (-2))	-0.0004*** (0.0006)	0.0000
D (LOG(GOLD))	-0.1065 (0.0752)	0.1629
D (LOG(GOLD (-1))	-0.2918*** (0.0886)	0.0018
D (LOG(GOLD (-2))	-0.2413*** (0.0855)	0.0068
D (LOG(GOLD (-3))	-0.3531*** (0.0866)	0.0002
CointEq(-1)*	-0.1009*** (0.0155)	0.0000
R-Squared	0.7689	
Adj. R-Squared	0.7284	

Notes: The parentheses are standard errors of coefficient variables (source: data processed)

Market volatility, as indicated by the CBOE VIX, has a significant negative effect on the NIFTY100ESG indices in the short term, both in the current period and at lag 2. This underscores the direct influence of global market uncertainty on sustainable indices. As a measure of anticipated volatility in the U.S. stock market, the CBOE VIX serves as a global benchmark for international investors, including those in India. The results suggest that heightened global market uncertainty reduces investor interest in sustainable stocks, which are often perceived as more sensitive to risk. This finding aligns with Nittayakamolphun et al (2024), which shows that all sustainable stocks from seven emerging markets were negatively affected by the VIX, indicating that increasing global market volatility consistently lowers the performance of sustainable stocks in the region. Although other studies, such as Naeem et al (2023), note that the effect of market volatility can vary depending on market conditions, the overall implication for the NIFTY100ESG indices is clear: heightened volatility deters investor confidence. Shaikh (2020) further explains that VIX is positively correlated with economic policy uncertainty (EPU), amplifying market volatility and creating broader implications for market-wide sustainability initiatives. The CBOE VIX can thus be used as an important risk indicator for investors in evaluating investment decisions in the sustainable market.

Gold prices have a significant negative impact on the NIFTY100ESG indices at all observed lags, suggesting that rising gold prices, which often reflect global uncertainty, may prompt investors to shift from sustainable stocks to gold as a safe-haven asset. This finding is consistent with Darsono et al (2024) research, which reported a negative impact of gold prices on the sustainable stock indices in

Indonesia. However, it differs from Abdullah & Aman (2024) findings, which noted that in developed markets, gold prices actually have a positive impact, especially at low gold prices. Additionally, Sharma et al (2024) observed that gold acts as a net receiver in financial markets and shows an inverse relationship with ESG stocks, making it a valuable asset for portfolio diversification, especially during market turmoil. The practical implication is that gold prices can serve as a useful indicator of market risk, enabling investors to adjust their sustainable portfolio allocations accordingly.

These results confirm that sustainable equity markets like the NIFTY100ESG remain sensitive to global risk factors despite operating within a sustainability framework. Siddiqui & Roy (2019) It has been highlighted that gold serves as a safe haven and a store of value during periods of uncertainty, reinforcing its role as a competing asset against sustainable stocks. Similarly, Kumar et al (2023) emphasize that fluctuations in oil and commodity prices also directly influence exchange rates and sustainable market performance, especially in emerging economies like India. The practical implication is that investors can use macroeconomic indicators such as exchange rates, market volatility, and gold prices as risk assessment tools in making investment decisions. Nevertheless, further research is necessary to explore how different sectors within the indices respond to these factors and to assess the impact of long-term volatility on the overall performance of the indices.

Table 5. Result of Long-run ARDL Estimation

ARDL (3, 1, 0, 3, 4, 0) Based on Values od AIC Dependent Variables: NIFTY100ESG

Variable	Coefficient	Prob.
LOG(EXRATE)	-0.7206 (1.3547)	0.5971
EPU	0.0028 (0.0019)	0.1599
CBOEVIX	-0.0138* (0.0081)	0.0954
LOG(GOLD)	1.6866*** (3.0049)	0.0041
LOG(OIL)	0.1704 (0.1838)	0.3583
C	-1.9262 (3.1194)	0.4526

Notes: The parentheses are standard errors of coefficient variables (source: data processed)

Table 5 shows the long-term results of the ARDL method. The estimation shows that the logarithmic exchange rate variable (LOG(EXRATE)) indicating that exchange rates do not have a significant impact on the NIFTY100ESG indices in the long run. The economic policy uncertainty (EPU) suggesting a positive but insignificant effect. Conversely, the CBOE VIX variable (CBOEVIX) exhibits a significant negative effect, with a coefficient of -0.0138 (p = 0.0954). Meanwhile, the logarithmic gold price (LOG(GOLD)) shows a significant positive relationship with the indices, with a coefficient of 1.6868 (p = 0.0041). On the other hand, the logarithmic WTI oil price variable (LOG(OIL)) indicating no significant impact on the indices in the long run. The negative but insignificant effect of exchange rates on the NIFTY100ESG indices suggests that currency depreciation might slightly suppress stock market performance by increasing import costs and inflation (Liao et al., 2019).

This finding aligns with Darsono et al (2023), who identified a negative relationship between exchange rates and volatility in the Asian sustainable stock market, and Mroua & Trabelsi (2020) who reported similar effects on Indian equity returns. The findings are further supported by Chellaswamy et al (2020) who reported no significant impact of exchange rates on nifty indices in India, and de Oliveira et al (2020), who found sustainability indices in China similarly unaffected, likely due to hedging strategies and a focus on domestic markets by companies in these indices. The negative coefficient indicates that currency depreciation may reduce investor confidence and raise operating costs for import-dependent companies, aligning with economic theories that link exchange rates to trade competitiveness and financial stability. However, the insignificance in this context likely reflects the hedging strategies of ESG-listed firms and their stronger reliance on domestic markets, which buffer them from the full impact of exchange rate fluctuations.

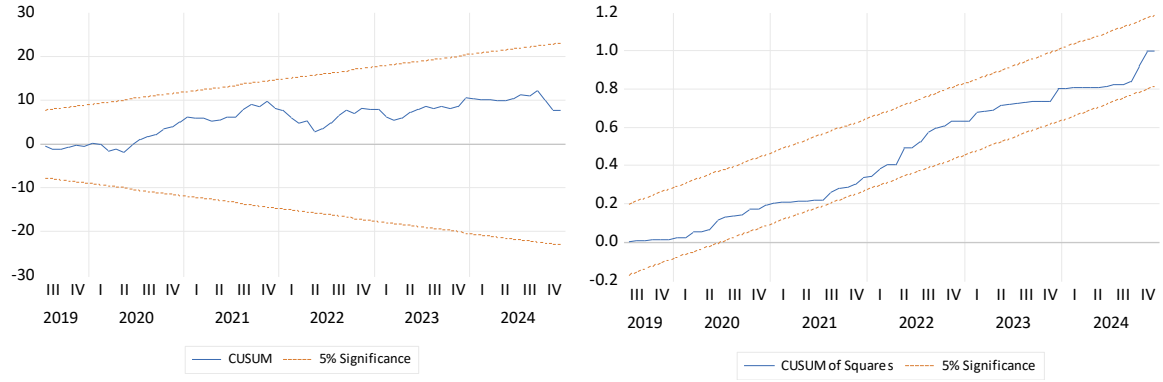
The positive but insignificant effect of EPU on the NIFTY100ESG indices in the long run suggests that while economic policy uncertainty can influence investor sentiment, its impact on ESG indices may be limited due to the perceived stability of companies within these indices. This finding aligns with research that reported a positive long-term relationship between EPU and the sustainability stock market in Indonesia (Darsono et al., 2024) and a similar positive effect on the sustainable stock market in Thailand (Nittayakamolphun et al., 2024). Furthermore, EPU can motivate firms to enhance their ESG performance, particularly in environmental and social dimensions, as companies seek to mitigate risks, attract investment, and improve their sustainability profile under uncertain conditions (Wu et al., 2024). Similarly, heightened EPU can drive firms to invest in innovative responses to maintain credibility and differentiate themselves in competitive markets, supporting the legitimacy theory that links ESG initiatives to long-term financial performance (Farooq et al., 2024). However, the insignificance observed in this study may reflect investors' adaptation to economic uncertainty in India, where ESG investments are viewed as safer options amidst market volatility. The results underline the importance of stable and transparent policy frameworks in fostering investor confidence and supporting long-term commitments to sustainability initiatives.

The significant negative impact of CBOE VIX on the NIFTY100ESG indices suggests that global instability reduces the performance of sustainable stocks. This finding is supported by Nittayakamolphun et al. (2024), who noted that VIX negatively affects sustainable stocks in emerging markets, and de Oliveira et al. (2020), who found a long-term negative impact of VIX on sustainability indices. Shaikh (2020) explained that VIX, correlated with economic policy uncertainty, amplifies market volatility and influences investor sentiment across asset classes, including equities, which can destabilize sustainability initiatives. Vuong et al (2022) VIX rising levels predict declining market returns and increase external capital costs, pressuring companies to delay investments and undermining sustainability. These results suggest that companies in ESG indices must prioritize transparency and resilience to mitigate the adverse effects of market volatility and maintain investor confidence. Effective risk management strategies tailored to global market conditions could enhance the stability and attractiveness of ESG investments.

Gold prices have a significant positive impact on the NIFTY100ESG indices in the long run, reflecting their role as a safe-haven asset during periods of economic uncertainty. This finding is supported by Darsono et al (2022) who observed a long-term positive influence of gold prices on sustainable stock returns in four countries (e.g., China, Brazil, the US, and India), attributing this to their status as major gold producers and consumers. Singhal et al (2019) similarly reported that rising gold prices positively affect stock market performance in emerging economies. Siddiqui & Roy (2019) highlighted gold's function as a hedge against inflation, with its price benefiting from currency depreciation, such as a weak USD, driving demand and equity market performance. Sharma et al (2024) further emphasized that gold strengthens its connection with ESG stocks during global crises, reinforcing its role as a stabilizing asset. In India, the world's second-largest gold consumer, this positive impact reflects gold's cultural and financial significance, which drives investor confidence in ESG investments during periods of uncertainty. These findings underline the importance of monitoring gold prices as a reliable indicator for predicting long-term ESG performance and crafting resilient investment strategies.

WTI oil prices have a positive but insignificant impact on the NIFTY100ESG indices in the long run, indicating that while fluctuations in oil prices may influence the market, their effect on ESG indices remains limited. This finding is consistent with Darsono et al (2022), who observed that oil prices in India positively affect sustainable stock returns, though the relationship is not statistically significant. The limited impact could be attributed to the composition of ESG indices, which prioritize companies in more sustainable sectors that are less directly affected by oil price volatility. Sharma et al. (2024) noted that crude oil acts as a net transmitter in financial markets, with time-varying spillover effects on ESG stocks, particularly during periods of geopolitical tension. Additionally, Kumar et al (2023) highlighted the indirect effects of oil prices on the broader economy in oil-importing countries like India, such as currency depreciation and inflationary pressures. These results suggest that ESG indices in India maintain stability despite oil price fluctuations, underscoring their potential as a resilient investment option. Future research should examine the interplay between oil prices, exchange rates, and sustainable investments to provide deeper insights into their interconnected dynamics. The results of this study reinforce the view that ESG indices offer relative stability to some external risks, although they remain vulnerable to global market uncertainty. This study has several practical implications, such as the importance of strengthening transparency and stability of company

performance in ESG indices to attract investors during periods of volatility. In addition, gold can be used as an important indicator in planning investments in sustainable stocks.



CUSUM Test CUSUM of Square Test

Figure 1. Stability Test for ARDL

The final stage in the ARDL approach is to conduct a model stability test. This test aims to evaluate the stability of the estimated coefficients in the model. Model stability can be analyzed through CUSUM and CUSUM squared graphs. If the graph remains within the significance line at a 5% confidence level, then this indicates that the model used is stable. Figure 1 shows that the ARDL (3, 1, 0, 3, 4, 0) model tested is in a stable condition. The CUSUM graph remains within the 5% significance line limit throughout the observation period, indicating that the model coefficients are stable without significant structural changes. The CUSUM of Squares graph also shows stability with a line that remains within the 5% significance limit for most of the analysis period, although it approaches the limit at the end of the observation. Overall, the model can be declared stable, but the potential for instability at the end of the period on the CUSUM of Squares graph needs to be considered for further analysis.

5. Conclusion

This study provides valuable insights into the macroeconomic factors that influence the performance of the NIFTY100ESG index, a key benchmark for sustainable investment in India. By applying the ARDL model, the analysis reveals that exchange rate fluctuations, market volatility, and gold prices play significant roles in shaping the index both in the short and long term. In the short run, currency depreciation tends to negatively affect the index by increasing import costs and inflation, which in turn reduces investor confidence in ESG stocks. Similarly, market volatility, as indicated by the VIX, contributes to declines in the index, reflecting global uncertainty and risk aversion that can lead to capital outflows from sustainable investments. Meanwhile, gold prices show a dual impact—acting as a destabilizing factor in the short term but providing a stabilizing effect over the long term. This suggests that during economic uncertainty, investors tend to shift their funds away from ESG stocks and into gold as a safe-haven asset.

The findings of this study contribute to the understanding of sustainable investment in several ways. First, they highlight how exchange rate fluctuations pose a substantial risk to ESG stocks, making it essential for investors and financial institutions to adopt hedging and diversification strategies to manage currency-related risks. Second, the study confirms that global market volatility has a significant impact on sustainable investments, reinforcing the need for policies that promote stability and reduce investor uncertainty. Lastly, the research sheds light on the role of gold as a risk indicator, demonstrating its long-term stabilizing effect on sustainable investments and providing investors with insights into how macroeconomic conditions influence ESG market dynamics. These insights are particularly useful for policymakers, financial institutions, and investors looking to strengthen the resilience of sustainable investments in emerging markets like India.

To create a more stable and attractive investment environment, it is crucial to implement policies that mitigate macroeconomic risks. One key step is to maintain exchange rate stability through prudent foreign exchange interventions while encouraging companies to adopt hedging mechanisms to manage currency risks effectively. Additionally, financial institutions can develop risk mitigation tools, such as volatility-adjusted ESG investment models and derivatives, to help investors navigate periods of economic instability. Given the long-term stabilizing effect of gold, integrating gold-backed

investment instruments, such as green bonds linked to gold reserves, can serve as a useful diversification strategy. Strengthening ESG governance through enhanced transparency, better disclosure standards, and regulatory stability will further boost investor confidence. Providing tax incentives and financial support for companies with strong ESG commitments can also encourage sustainable investment and drive long-term capital into environmentally and socially responsible businesses. By implementing these measures, stakeholders can enhance the resilience of the NIFTY100ESG index while reducing the risks posed by external economic fluctuations. Strengthening the investment landscape for ESG assets not only increases investor confidence but also contributes to India's broader economic and environmental goals, ensuring a sustainable and stable financial future.

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