IJEEP
INTERNATIONAL JOURNAL OF ENERGY ECONOMICS AND POLICY
EJ EconJournals
ISSN: 2146-4553

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2024, 14(6), 513-522.

Assessing the Role of Sharia-Compliant Investments in Promoting Clean Energy and Sustainable Economic Development: A Study of Asia's Financial and Renewable Energy Sectors

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Received: 16 June 2024 **Accepted:** 10 October 2024 **DOI:** https://doi.org/10.32479/ijeep.17018

ABSTRACT

This study investigates the asymmetric impact of the Islamic stock market on clean energy prices and green economic development in the Asia-Pacific region using daily data from January 01, 2022, to May 31, 2024. Employing the Non-linear Autoregressive Distributed Lag (NARDL) model, we examined both long-term and short-term relationships between these variables. Our findings reveal significant cointegration, indicating a stable long-term relationship. In the long term, Islamic stock prices positively influence the clean energy market and green economic development, suggesting that Islamic finance can effectively support sustainable initiatives and environmental goals in the region. However, minor negative variations were observed, with an insignificant negative effect on green economic development over extended periods. In the short term, Islamic stock prices also demonstrate a significant positive effect on clean energy and green economic growth, highlighting their role in fostering immediate advancements in sustainable economic activities. Despite this, there are minor negative impacts, indicating that fluctuations in Islamic stock prices may occasionally result in short-term setbacks for clean energy and green economic development. Overall, the findings underscore the crucial role of the Islamic stock market in promoting sustainable economic growth and environmental sustainability in the Asia-Pacific region. The presence of minor negative effects both in the long and short term suggests the need for careful monitoring and management of stock market fluctuations to mitigate any potential adverse impacts on sustainability efforts. This study adds to the existing body of knowledge by emphasizing the importance of considering the unique dynamics of Islamic finance in the context of sustainable economic development.

Keywords: Clean Energy, Green Economic Growth and DJ Islamic Stock Prices, Asymmetric Analysis, Nonlinear ARDL
JEL Classifications: G01, G15, Q012

1. INTRODUCTION

Renewable energy and green growth are vital for the survival and advancement of human society, making them key components of national strategic resources. However, fossil fuels are a leading source of carbon dioxide (CO_2) emissions, which greatly contribute to global warming (Stern, 2007). If greenhouse gas emissions continue to rise, the effects could be disastrous. To address this, the United Nations aims to limit global temperature increases to 1.5° by 2050, emphasizing the critical need for renewable energy. To tackle this global issue, a new energy framework based on renewable sources must replace the current fossil fuel-based system. This shift is crucial for stabilizing and developing national economies while safeguarding the future of our planet. Over the last decade, the renewable energy sector has seen significant growth driven by environmental concerns about conventional

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energy sources and government policies supporting clean energy (Wang et al., 2019).

In the context of globalization, the rise of Islamic stock market as a significant aspect of financial relations has sparked increasing interest in its unique potential. The share of Islamic stock market within the global financial system is consistently growing, with an annual value reaching $2 trillion (Paltrinieri et al., 2019). The global community is currently experiencing the aftermath of recent economic, financial, and social crises. Notable examples include the 1998 Asian financial crisis, the global financial downturns beginning in 2008 following the Great Depression, and the ongoing COVID-19 pandemic. These events have led researchers and scholars to focus more on the interdependence between energy market and Islamic stock markets (Bahloul and Khemakhem, 2021; Hachicha et al., 2021; Salisu et al., 2020; Boubaker and Rezgui, 2020). The challenges during these recession periods are critical for several reasons. Firstly, the global financial and economic crises, along with the European debt crisis, have intensified the correlations between equity returns in numerous countries, illustrating the transmission of financial volatility internationally. Therefore, it is crucial to explore the impact of uncertainty in Islamic stock prices on green energy markets amid the post pandemic. Analyzing the shifts in the interdependence between stock and renewable energy market highlights the importance of international diversification for potential investors, particularly within Islamic stock markets.

The Asia-Pacific region, with its diverse and dynamic economies, is increasingly focusing on sustainable development and green economic growth. In this context, the role of Islamic finance, particularly the Islamic stock market, in promoting clean energy and green growth has become a significant area of interest. However, several challenges and issues need to be addressed to fully harness the potential of Islamic finance in this domain. One of the primary challenges is the lack of comprehensive regulatory frameworks that integrate Islamic finance principles with green finance guidelines. Islamic finance, governed by Shariah law, emphasizes ethical investing and prohibits investments in businesses that deal with alcohol, gambling, and other activities considered harmful. This ethical foundation aligns well with the principles of green finance, which focus on sustainability and environmental protection. However, the existing regulatory frameworks in many Asia-Pacific countries do not adequately address the convergence of these two financial streams, leading to a fragmented market and limited investment opportunities (Avazkhodjaev et al., 2022; Balli et al., 2019; Avazkhodjaev et al., 2024).

Another significant issue is the limited availability of green Sukuk (Islamic bonds) in the market. While green Sukuk have the potential to attract significant investments for clean energy projects, their issuance remains relatively low compared to conventional green bonds. This is partly due to the higher costs and complexities associated with structuring green Sukuk, as well as a lack of awareness and expertise among issuers and investors. Consequently, many clean energy projects in the region struggle to secure adequate funding, hindering their development and implementation. Hovewer, the Islamic stock market continues to witness significant activity despite challenging financial conditions over the past year. This growth is expected to continue, driven by the ongoing demand for sustainable finance products, including sustainable sukuk to finance green, sustainable projects, such as the Republic of Indonesia's Sovereign Green Sukuk issuances, Al Rajhi Bank's Sustainable Sukuk, and DP World's Green Sukuk. Furthermore, economies highly dependent on hydrocarbon revenues, such as those in the GCC states, Malaysia, and Indonesia—traditional hubs for Islamic finance—are committing to ambitious emissions reductions and diversifying their energy mix and economies. This underscores the increasing relevance of Islamic finance as a tool for funding the energy transition.

The uncertainty surrounding rising or falling green energy market significantly impacts not only Islamic securities but also the hedging strategies that international investors frequently advocate. Historically, empirical studies have concentrated on conventional stock markets, particularly in energy sectors, but research on Islamic stock markets has gained momentum over the past 3 years. For instance, recent studies have explored the relationship between economic fluctuations and stock markets, including Jones and Olson (2013) for the US market, Chang et al. (2015) for OECD countries, Guo et al. (2017) for BRICS and G7 countries, and Christou et al. (2017) for Pacific Rim markets. Additionally, other studies have examined the link between stock market returns and energy prices (Sadorsky, 1999; Choi and Hammoudeh, 2010; Salisu and Oloko, 2015), while further research has investigated the impact of investor sentiment on financial and energy markets (Avazkhodjaev et al., 2022; Avazkhodjaev et al., 2024; Avazkhodjaev et al., 2022; Wang et al., 2013; Aloui et al., 2018; Bekiros et al., 2016; Perez-Liston et al., 2016; Dash and Maitra, 2017; Hasanov and Avazkhodjaev, 2022; Shakhabiddinovich et al., 2022).

In recent years, Islamic stocks have seen a surge in popularity, especially following the global financial crisis (GFC) of 2008-2009 and the European debt crisis (EDC) of 2011-2012 (Bossman, 2021). Research by Shahzad et al. (2018) and Balli et al. (2019) indicates that Islamic stocks tend to outperform conventional stocks during financial crises. These stocks and indices offer investors a means to align their investments with their religious beliefs. As traditional financial markets have faced declining confidence, Islamic stock markets have emerged as a key option for constructing optimal investment portfolios in Islamic financial markets (IFM), according to Ng et al. (2020). Studies by Shahzad et al. (2018), Balli et al. (2019), and Hassan et al. (2020) suggest that Islamic stocks cater to both risk-tolerant and risk-averse investors, particularly during the GFC, highlighting their growing importance as an investment vehicle. The resilience of Islamic financial markets during the GFC is often attributed to the inherent risk-sharing element in Islamic securities contracts (Ejaz and Khan, 2014). During the COVID-19 pandemic, Islamic stock markets exhibited less volatility across all frequencies compared to G7 stock markets, demonstrating their relative resilience (Bossman et al., 2021).

Moreover, Islamic stock markets are relatively new and steadily gaining prominence at both regional and global stock market

levels. Studies by Jawadi et al. (2014), Khazali et al. (2016), and Mensi et al. (2017) highlight their increasing popularity, driven by their distinctive performance and efficiency compared to conventional markets. Despite this, Islamic markets have received comparatively less attention in academic research, necessitating a closer examination of how renewable energy market impact them. In another context, Shaktawat and Vadhera (2022) and Rasoulinezhad and Taghizadeh-Hesary (2022) emphasize the centrality of green finance in global discussions, aimed at transitioning towards low carbon emissions and green economic growth through substantial investments in green energy projects. Islamic finance instruments, as noted by Markom et al. (2012), Adelekan et al. (2013), and Lai (2015), are considered highly suitable for supporting investments in the clean energy sector. Already applied in this sector, Islamic finance instruments could play a pivotal role in accelerating project financing for clean energy initiatives. Furthermore, while Islamic bonds traditionally serve as safe havens in normal market conditions, Rizvi et al. (2022) highlight cryptocurrencies emerging as safe-haven assets during bearish or highly volatile periods. Additionally, Yousaf and Yarovaya (2022) suggest that adding Islamic Sharia-based cryptocurrencies to Islamic sector equity portfolios could enhance hedging efficiency, both before and during the COVID-19 pandemic.

In the context of Islamic securities markets, there have been limited empirical studies exploring the causal links between renewable energy and green growth and Islamic stock markets, with findings showing a mixed picture. Bahloul and Khemakhem (2021) discovered that commodity indices can exert significant upward shocks on Islamic stock markets. Conversely, Boubaker and Rezgui (2020), using Windowed Scalogram Difference and Wavelet Coherence approaches, found that investors in Islamic stock markets do not heavily rely on prices of commodities like gold, oil, and gas. Similarly, Khan and Masih (2021), employing wavelet analysis, investigated the co-movements between Islamic stock indices and energy as well as precious metal indices during the global financial crisis from 2008 to 2012. Therefore, it's timely to delve into less explored markets such as green energy and Islamic stocks. The unique response of Islamic stock markets to clean energy prices can be explained by theories like gradual information diffusion and conservatism (Hong and Stein, 1999). Interestingly, Islamic stock markets are less affected by information asymmetry due to their adherence to profit and loss-sharing principles. However, the existing literature on the relationship between Islamic stocks and energy stocks presents inconsistent findings, underscoring the need for further comprehensive studies using advanced methodologies.

This paper distinguishes itself from other empirical studies on this topic by using daily data to explore the impact of the Islamic stock market on clean energy prices and green economic growth. It makes three key contributions. First, it highlights the role of financial markets, particularly the Islamic stock market, in supporting the growth and capital circulation of the clean energy market and green economic development within the broader economy. While previous studies have investigated the link between energy consumption and economic growth, focusing on both nonrenewable and renewable energy markets, there is a notable research gap regarding the relationship among the Islamic stock market, clean energy, and green economic growth. This study addresses that gap by focusing on Islamic stock and renewable energy markets, which have been largely overlooked in prior research.

Second, we contend that analyzing the relationship between these variables in a nonlinear context is crucial for at least two reasons: (1) time series can exhibit hidden cointegration if the positive and negative components are cointegrated (Granger and Yoon, 2002), and (2) asymmetry is a type of nonlinearity that affects market dynamics, especially during periods marked by significant events like the pre-and post-pandemic periods. To achieve these objectives, we utilize the Nonlinear Autoregressive Distributed Lag (NARDL) approach proposed by Shin et al. (2014), which allows testing for long-run and short-run asymmetries. Unlike standard cointegration techniques, this method accommodates time series with different orders of integration (Shin et al., 2014).

Third, while most studies on Islamic stock markets focus on a single type of clean energy price and green economic growth, this paper compares two renewable energy industries: stock prices of clean energy generation and green economic growth. We examine its asymmetric effects on clean enery and green growth. This analysis has the potential to inform future policy recommendations. Notably, our study uses indices from the renewable energy markets of Asia.

The rest of this paper is organized as follows: Section 2 presents a brief review of the literature. Sections 3 and 4 cover data and empirical methods, respectively. Section 5 discusses the empirical results and provides analysis. Finally, Section 6 offers concluding remarks and policy implications.

2. LITERATURE REVIEW

The advancement of sustainable development goals such as energy transition and carbon neutralization requires the implementation of various environmental projects. Due to the problem of the lack of sufficient capital for governments to invest in green projects, this issue has been studied by many scholars in recent decades. Generally, investment in green projects has been drawn to attention by many earlier studies. Studying this issue is essential primarily due to the financial constraints in many countries. Earlier studies documented a causal relationship between Islamic stocks and energy markets. For example, Khan and Masih (2021) found that the relationship between commodities and Islamic equities is highly volatile and varies over time. Nagayev et al. (2016) used the MGARCH-DCC and Wavelet Coherence approaches to study the time-varying causal nexus between commodity markets and the Dow Jones Islamic market index. Similarly, Mensi et al. (2017) demonstrated that Islamic financial markets, particularly in the energy and technology sectors, are receivers of risk spillovers. They employed the spillover index from Diebold and Yilmaz (2014) to determine the dynamic interconnectedness among the DJ Islamic stock market and energy markets.

Ghallabi et al. (2024) examined the dynamics of downside and upside risk spillovers between renewable energy markets and Islamic stock markets in the context of the Russia-Ukraine crisis. By employing the VAR-ADCC model and conditional value at risk (CoVaR) techniques, the study estimates the extent of these risk spillovers. The findings indicate that risk spillovers are predominantly asymmetric, with the degree of asymmetry varying across different distributions and sub-samples before and during the conflict. Significantly, the research reveals that the magnitude of downside and upside risk spillovers between renewable energy and Islamic stock markets in Malaysia, Turkey, and India remains insignificant during the Russia-Ukraine war compared to the pre-crisis period. This suggests that renewable energy markets in these countries are relatively unaffected by fluctuations in Islamic stock markets during the conflict. Additionally, the study highlights that Canadian Islamic stock markets offer diversification benefits against extreme downside risk spillovers from renewable energy markets.

Moreover, Hassan et al. (2020) authors employ threshold GARCH (TGARCH) and generalized forecast error variance decomposition methodologies to calculate time-domain and frequency-domain volatility spillovers. The research focuses on Islamic and conventional stock indices, alongside crude oil, within the BRICS nations (Brazil, Russia, India, China, and South Africa). The findings indicate that long-term components predominantly drive total volatility spillovers. This suggests that these assets are particularly suitable for investors with short- to medium-term investment horizons. However, the analysis also reveals a significant increase in the magnitude and speed of volatility spillovers during the global financial crisis. This spike implies that investors in Brazil, Russia, and South Africa should promptly rebalance their portfolios during such periods to mitigate risk. Furthermore, a dynamic covariance analysis illustrates that the covariance between Islamic and conventional stock index returns is highest during the crisis period, with a notable increase.

Furthermore, Shaktawat and Vadhera (2022), along with Rasoulinezhad and Taghizadeh-Hesary (2022), highlighted that green finance is central to global discussions aimed at transitioning to low carbon emissions and sustainable development, necessitating significant investments in green energy projects. According to Markom et al. (2012), Adelekan et al. (2013), and Lai (2015), Islamic finance is well-suited to support investments in the clean energy sector, as Islamic finance instruments have already been utilized in this area. Consequently, Islamic finance could expedite project financing in the clean energy sector. Additionally, Rizvi et al. (2022) confirmed that while Islamic bonds serve as a safe haven under normal market conditions, cryptocurrencies have emerged as safe-haven assets during periods of bearish markets or extreme volatility. Yousaf and Yarovaya (2022) found that incorporating Islamic Sharia-based cryptocurrencies into Islamic sectorial equity portfolios can help investors mitigate risk during both the pre-COVID and COVID-19 periods.

Using a rolling-window procedure with GARCH family models with DCC and ADCC specifications, Hachicha et al. (2021) examined the conventional and DJ Islamic stock markets, optimal hedging with gold and crude oil, and selected emerging countries' sectoral indices (health care, raw materials, and telecommunications industries). The authors concluded that these selected sectoral indices were the most effective hedging instruments for conventional and Islamic portfolios, showing the highest hedging effectiveness. Likewise, Erdogan et al. (2023) analyzed the connections between uncertainty impacts in Islamic stock and currency markets across Turkey, Malaysia, and India. Utilizing variance non-causality analysis, they discovered that uncertainty effects from Islamic financial markets impacted the exchange market solely in Turkey. The outcomes from time-varying tests demonstrated a correlation between exchange rate risk and Islamic financial markets during specific periods. On the other hand, Alkhazalia and Zoubib (2020) investigated the diversification advantages of incorporating gold into DJ Islamic stock portfolios through a stochastic dominance approach. Their research showed that portfolios containing both gold and Islamic stocks outperformed those without gold. Additionally, they observed that this dominance pattern was present during the 2007-2009 global financial crisis in all gold holdings. The authors recommended that investors consider including gold in Islamic stock portfolios for enhanced diversification.

Despite various studies examining the influence of the Islamic stock market on the clean energy market and green economic growth, this area of research is still in its early stages of development. Given the lack of literature, especially on Islamic stock indices, this paper explores the long-run and short-run effects of the Islamic stock market on clean energy and green economic development using the Nonlinear ARDL-VECM model. Additionally, we investigated whether asymmetric models perform better than symmetric models.

3. DATA AND PRELIMINARY STATISTICS

We employ three key stock indices from the Islamic stock market to represent the renewable energy sector and green economic growth. First, we utilize the Asia-Pacific Dow Jones Islamic stock market index. Second, we use the Clean Energy Focused Asia index, which tracks sectors of the Green Economy that support energy generation through non-fossil-based sources. This index encompasses sectors such as Renewable Energy, Energy Efficiency, Advanced Materials, and Bio/Clean Fuels. Lastly, we select the Index of Green Economy for Asia as an indicator of green economic development. This market-capitalization-weighted index monitors the performance of companies within industries associated with the sustainable development economic model. It serves as a global benchmark for companies in Asia that aim to reduce their reliance on fossil fuels in products, services, and lifestyles. The data period for all variables extends from January 01, 2022, to May 31, 2024. We obtained this data from www.investing.com and the Nasdaq Global Index database, and all data are expressed in US Dollars to ensure consistency across the dataset.

Table 1 displays the descriptive statistics for the Islamic stock market, clean energy, and green economic development throughout the entire period. The table reveals that the daily

averages for all series are lower than their respective standard deviations. It is clear from the data that the Asia-Pacific market exhibits both high and low mean values for green economic development. When comparing the maximum and minimum values of GED in the selected markets, we observe that while these values are relatively consistent across markets, the maximum value of all selected variables surpasses that of other series studied. This suggests that the Asia-Pacific market prioritizes the development of the green economy and clean energy through the Islamic stock market.

It was noted that the Islamic stock market shows a positive return that exceeds the average return of renewable energy and green economic growth in the study. Furthermore, the standard deviation of the Islamic stock market is lower compared to that of returns from clean energy prices and green economic development. This indicates that Islamic stocks are both more profitable and less risky than the other variables studied over the sample periods. Significant kurtosis and skewness were observed in the price returns of Islamic stocks, clean energy, and green growth. The Jarque-Bera statistics confirmed that the returns of the selected variables are not normally distributed.

To establish the meaningful non-linear framework, it is crucial that all series considered exhibit stationarity. Therefore, we initially conduct unit root tests using the conventional augmented Dickey-Fuller (ADF), Phillips–Perron (PP), and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) tests on the series under investigation. These tests aim to ascertain the presence of a unit root. The results, presented in Table 2, indicate that none of the variables are stationary in their original levels. However, when we examine their first differences, including intercepts and trends, the variables demonstrate stationarity. It is noteworthy that when variables are integrated of order one or higher (denoted by I(I)), the NARDL approach yields results comparable to other cointegration methods (Fousekis et al., 2016). Therefore, we proceed with testing for cointegration within a nonlinear framework.

Table 1: Descriptive statistics for selected variables

Series	IMA	CENA	GED
Mean	7.6561	6.6362	6.7877
Median	7.6484	6.5233	6.7304
Maximum	7.9047	7.1573	7.1937
Minimum	7.4578	6.1612	6.5129
St. Deviation	0.0748	0.2757	0.1771
Skewness	0.6642	0.2399	0.4129
Kurtosis	4.8066	1.6623	1.8603
Jarque-Bera	132.00***	52.931***	51.921***

Significance level *, **, ***indicated 10%, 5% and 1%, respectively. Here, $K_{s,t}$, $K_{g,t}$ and $K_{e,t}$ denote log changes for prices of Islamic stock, gold and energy, respectively

The bound testing procedure confirms the presence of a long-term and short-run asymmetric relationship between the Islamic stock market, clean energy prices, and green economic development. Eq. (5). The empirical estimates of nonlinear specifications are summarized in Table 3. F_{PSS} denotes the F-statistic proposed by Pesaran et al. (2001) for testing the null hypothesis of no cointegration, while t_{BDM} is the *t-statistic* proposed by Banerjee et al. (1998) for testing the null of no long-run relationship. The results of both tests shows that the presence of nonlinear short-run positive relationship between selected variables under study.

4. EMPIRICAL METHODOLOGY

We utilize the nonlinear autoregressive distributed lag (NARDL) model to explore the asymmetric long-term and short-term effects of the Islamic stock market on clean energy and green economic development. The NARDL methodology, introduced by Shin et al. (2014), facilitates the examination of these asymmetries over different time horizons. This approach is known for producing robust empirical results even with small sample sizes (Chatak and Siddiki, 2001; Narayan and Narayan, 2007; Pesaran et al., 2001) and is applicable regardless of the integration order of the series, as long as it is integrated up to the first order. The integration order can be confirmed using unit root tests. Notably, when time series demonstrate cointegration through their positive and negative fluctuations (Granger and Yoon, 2002), this suggests the presence of nonlinear cointegration.

4.1. Nonlinear Autoregressive Distributed Lag (NARDL) model

The NARDL approach enables the modeling of asymmetric cointegration through the use of positive and negative partial sum decompositions, allowing for the detection of asymmetric effects in both short-run and long-run contexts. Additionally, this method permits the joint analysis of non-stationarity and nonlinearity within the framework of an unrestricted error correction model. The specification of the nonlinear cointegration regression, as proposed by Shin et al. (2014), is as follows:

$$y_t = \beta^+ x_t^+ + \beta^- x_t^- + \quad (1)$$

were β^+ and β^- are long term parametres of kx1 vector of regressors x_t, decomposed as:

$$x_t = x_0 + x_t^+ + x_t^- \quad (2)$$

Where x_t^+ and x_t^- are the partial sums of positive or negative change in x_t, as follows:

Table 2: Results of unit root tests Results of unit root tests

Variable	ADF		PP		KPSS	
	Level	1st Diff.	Level	1st Diff.	Level	1st Diff.
IMA	−3.1042	−21.759***	−2.9560	−21.598***	0.4141	0.0589
CENA	−0.9893	−22.235***	−0.6192	−22.088	0.5005	0.1399
GEDA	−2.2972	−22.489***	−2.0297	−22.502***	0.4214	0.0386

***, **, * indicate 1%, 5% and 10% significance level, respectively. ADF, PP and KPSS are the empirical statistics of the Augmented Dickey–Fuller (1979), and the Phillips–Perron (1988) unit root tests, and the Kwiatkowski et al. (1992) stationarity test, respectively. The critical values of the KPSS unit root tests at 5% significance level are 0.463 and 0.146, respectively.

$$x_t^+ = \sum_{j=1}^{t} \Delta x_j^+ = \sum_{j=1}^{t} \max(\Delta x_j, 0) \quad (3)$$

$$x_t^- = \sum_{j=1}^{t} \Delta x_j^- = \sum_{j=1}^{t} \min(\Delta x_j, 0) \quad (4)$$

4.2. Nonlinear ARDL–ECM model

The NARDL (p,q) from of the Eq.(2), in the form of asymmetric error correction model (ECM) (Raza et. al, 2016) can be presented as follows:

$$\Delta y_t = \rho y_{t-1} + \theta^+ x_{t-1}^+ + \theta^- x_{t-1}^- + \sum_{j=1}^{p-1} \varphi_j \Delta y_{t-j}$$

$$+ \sum_{j=0}^{p} (\pi_j^+ \Delta x_{t-j}^+ + \pi_j^- \Delta x_{j-t}^-) + \varepsilon_t \quad (5)$$

Where $\theta^+ = -\rho\beta^+$ and $\theta^- = \rho\beta^-$. In nonlinear framework, the first two steps to ascertain cointegration between the varibales are same is in linear ARDL bound testing procedure i.e. estimation Eq. (5) using OLS and conduction the joint null ($\rho = \theta^+ = \theta^- = 0$) hypothesis test of no asymmetric relationship. However, in NARDL, the Wald test is used to examine the long-run ($\theta^+ = \theta^-$) and short-run ($\pi^+ = \pi^-$) aysmmetries in the relationship.

Finally, the asymmetric cumulative dynamic multiplier effects of a unit change in x_t^+ and x_t^- on y_t can be calculated as follows:

$$v_h^+ = \sum_{j=0}^{h} \frac{\partial y_{t+j}}{\partial x_t^+}, v_h^- = \sum_{j=0}^{h} \frac{\partial y_{t+j}}{\partial x_t^-}, h = 0,1,2 \quad (6)$$

where as $h = \infty$, the $v_h^+ \to \beta^+$ and $v_h^- \to \beta^-$. A mentioned above β^+ and β^- are the asymmetric long-run coefficients and here can be examines as $\beta^+ = -\theta^+/\rho$ and $\beta^- = -\theta^-/\rho$, respectively.

4.3. Generalized impulses response function analysis (GIRF)

To examine the time mode of the effects of Islamic stock price shocks on future behavior of clean energy price and green economic development, we employ the GIRF proposed by Koop et al. (1996). We created an analytical framework of impulse responses of Islamic stock price returns to one unit of lean energy price and green economic development under the VAR process. Following to Grier et al. (2004), the shock effects of Islamic stock price volatiltity on lean energy price and green economic development are marked through the conditional mean and with a lag through the second moment equation. As given in Grier et al. (2004) the GIRF of the paper is detailed as follows:

Table 3: Bounds tests for nonlinear specification

Dependent variable	$FPSS_{Nonlinear}$	t_{BDM}
IMA	4.7285***	−4.5765***
CENA	3.5550***	−3.7163***
GEDA	4.0802***	−4.3595***

Here, REG, CO and GDP represent log changes of renewable generation, carbon emission and green economic growth, respectively. 99% upper (lower) bound with k=4 is 5.06 (3.74). 95% upper (lower) bound with k=6 is 4.43 (3.15). ** Indicates significance at 5% level. *** Indicates significance of bound test at 1% level

$$GIRF_K(n, \varrho_t, \omega_{t-1}) = E[K_{t+n}|\varrho_t, \omega_{t-1}] - E[K_{t+n}|\omega_{t-1}] \quad (7)$$

where n = 0,1,2,3., thus the GIRF is conditional on ϱ_t and ω_{t-1} and constructed the responses by average future shocks given in the previous and present. Giving it, a natural reference point for GIRF is the conditional expectation of K_{t+n} given only the history ω_{t-1}, and in this shock response the current shock is also averaged out.

5. EMPIRICAL RESULTS AND DISCUSSION

In this section, we will comprehensively examine the empirical results derived from our model estimations. As noted in our introduction, our primary objective is to investigate the asymmetric impacts of Islamic stock prices on clean energy and green economic development, with a focus on the Asia-Pacific markets. We employ the NARDL model to analyze both the long-term and short-term asymmetric effects of Islamic stock prices on clean energy and green economic development. Finally, we performed a generalized impulse response function analysis for the Islamic stock market in response to a one-unit change in clean energy and green economic development within the Asia-Pacific market, utilizing the VAR process.

Upon confirming cointegration between the variables, we analyze the estimation results for the long-term and short-term asymmetric impacts of Islamic stock prices on clean energy and green economic development. Table 4 reveals that the Islamic stock market significantly positively influences the clean energy market and green economic development in the selected Asia-Pacific market. From another viewpoint, the Islamic stock market exhibits an insignificant negative effect on green economic development in the long run.

Similarly, the short-run dynamics are presented in the lower panel of Table 5. Our findings indicate that the short-run coefficients of Islamic stock prices have a significant positive effect on the clean energy market and green economic growth in the selected Asia-Pacific stock and commodity markets. Importantly, changes in the Islamic stock market have an insignificantly negative impact on the Asia-Pacific clean energy market and green economic development.

Additionally, we performed the Wald test to assess the suitability of a nonlinear model. The results rejected the null hypothesis of long-term and short-term symmetry between the positive and negative components of all examined variables. Our findings showed that the Islamic stock price consistently trends upward in

Table 4: Long-run coefficient estimates of the NARDL-VECM Model

Market	Variable	Coefficient	Probability
Asia-Pacific	LRCENA_POS	0.030693	0.0023
	LRCENA_NEG	0.060695	0.0148
	LRGRE_POS	−0.315750	0.0356
	LRGRE_NEG	1.637578	0.1340
	C	−0.064635	0.3516

Here, LCENA and LRGRE represent clean energy price and green economic development, respectively

Figure 1: GIRF of Islamic stock price under VAR process to a unit shock of clean energy price and green economic development. (a) The analytical framework of impulse responses for the long-run, (b) The analytical framework of impulse responses for the short-run

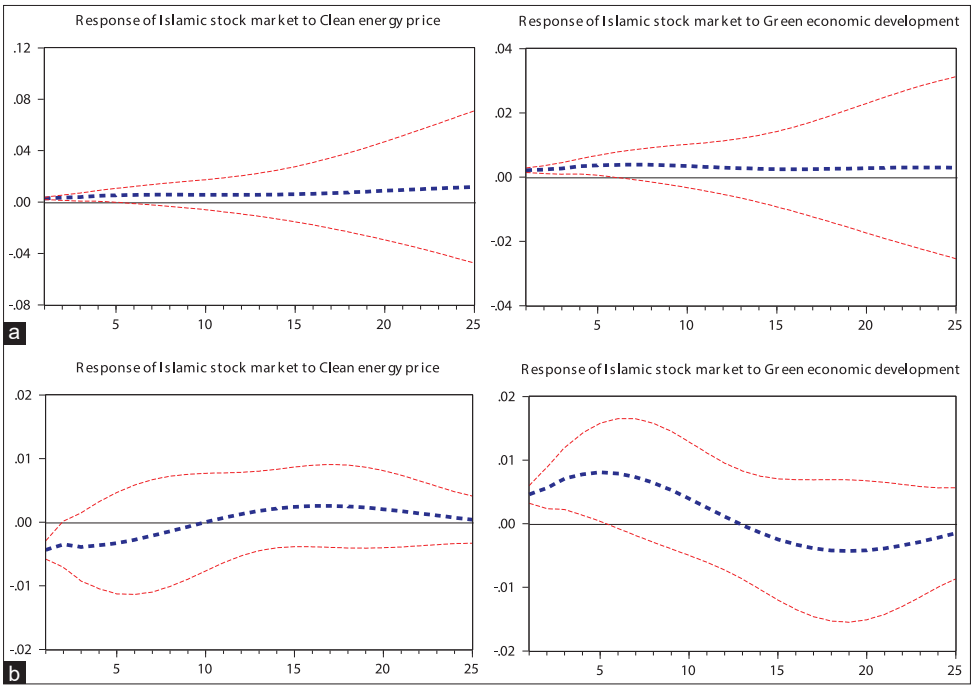

Table 5: Short-run coefficient estimates of the NARDL-VECM Model

Market	Variable	Coefficient	Probability
Asia-pacific	C	0.000419	0.4936
	DLCENA_POS	−0.143763	0.0028
	DLCENA_POS(−1)	−0.098655	0.0369
	DLCENA_NEG	−0.038769	0.4507
	DLRGRE_POS	0.731018	0.0000
	DLRGRE_POS(−1)	0.184723	0.0016
	DLRGRE_NEG	0.638857	0.4100
	DLRGRE_NEG(−1)	0.043813	0.2869
	DLRGRE_NEG(−2)	0.095606	0.0100
	DLRGRE_NEG(−3)	−0.058532	0.1112
	ECT	−0.001442	0.7744

Here, LCENA and LRGRE represent clean energy price and green economic development, respectively

both the long term and short term, with a minimal positive impact on green economic development. According to our knowledge, the influence of the Islamic stock price on the clean energy market and green economic development is positively asymmetric in both the short term and the long term.

As mentioned earlier, the empirical methodology section details the analytical framework of the Generalized Impulse Response Function (GIRF) of the Islamic stock market in response to one standard deviation shocks in clean energy prices and green economic growth within the vector autoregression process of the respective markets, as illustrated in Figure 1. In Figure 1, the solid blue line represents the response to a unit shock innovation, while the dashed red lines indicate the confidence intervals; each unit time horizon denotes a daily series. The results in Figure 1, Panel (a), indicate that innovation shocks in the Islamic stock market have a positive steady-state impact on clean energy prices and green economic development.

In Panel (b) of Figure 1, the short-term data indicates that the Islamic stock market has a consistently positive impact on clean energy, even though there's a slight dip at the start. When it comes to green economic growth, the positive effects of the Islamic stock market become evident about 13 months in, with an increase of up to 0.01% from the initial shock. However, these innovation shocks also show an unstable negative effect on green economic growth in the short term.

6. CONCLUSION AND POLICY RECOMMENDATIONS

As previously mentioned, some empirical studies have explored the relationship between the Islamic stock market and clean energy prices, but there is a gap in the research concerning these variables. This study addresses this gap by concentrating on Islamic stock markets, which have been largely overlooked in prior research. The Non-linear Autoregressive Distributed Lag (NARDL) model, suitable for examining long-term and short-term relationships between variables, has been used in this study to determine the asymmetric impact of the Islamic stock market on clean energy prices and green economic growth.

Based on our empirical results, we observe both long-term and short-term asymmetric impacts of Islamic stock prices on clean energy and green economic development within the Asia-Pacific region.

Our analysis confirms cointegration between the variables, indicating a stable long-term relationship. The results show that in the long term, the Islamic stock market significantly positively influences the clean energy market and green economic development in the selected Asia-Pacific market. This positive

impact underscores the potential of Islamic finance to support sustainable initiatives and environmental goals in the region. However, it is also observed that the Islamic stock market has an insignificant negative effect on green economic development in the long run, suggesting that while the overall influence is beneficial, there may be minor negative variations over extended periods.

In the short term, our findings reveal that the coefficients of Islamic stock prices have a significant positive effect on the clean energy market and green economic growth in the selected Asia-Pacific stock and commodity markets. This indicates that changes in Islamic stock prices are beneficial for immediate advancements in clean energy and sustainable economic activities. Nonetheless, there are also insignificant negative impacts noted in the short run, implying that short-term fluctuations in the Islamic stock market may occasionally result in minor negative effects on clean energy and green economic development.

In conclusion, the empirical evidence highlights that the Islamic stock market plays a crucial role in promoting clean energy and green economic development in the Asia-Pacific region. While the overall impact is significantly positive, some minor inconsistencies and negative effects are observed both in the long and short term.

Based on the empirical results provided, the following policy recommendations can be made to leverage the positive impacts of the Islamic stock market on clean energy and green economic development in the Asia-Pacific market:

6.1. Promote Islamic Financial Instruments in Clean Energy Investments

Given the significant positive impact of the Islamic stock market on clean energy, it is crucial to promote Islamic financial instruments. Policymakers should incentivize Islamic financial institutions to invest in clean energy projects and develop Sharia-compliant green bonds (Sukuk).

6.2. Facilitate Market Integration and Awareness

Enhancing integration between Islamic financial markets and green economic sectors can amplify positive impacts. Regulatory harmonization and cross-listing initiatives can foster integration (El-Komi and Croson, 2013). Additionally, increasing awareness of Islamic finance's potential for sustainable development among investors and stakeholders can drive more informed investment decisions.

6.3. Support Long-term and Short-term Investment Strategies

Policies should encourage long-term investments through attractive returns offered by Islamic finance instruments and support short-term investment opportunities with efficient capital flow mechanisms. Long-term investments are critical for sustainable growth, while short-term strategies can address immediate market needs.

6.4. Develop a Favorable Regulatory Environment

Creating a supportive regulatory environment is essential for the sustained positive impact of Islamic finance on green development. Clear and consistent frameworks aligning Islamic finance with sustainable development goals can provide the necessary stability by United Nations Environment Programme, 2016. Tax incentives and subsidies for green projects financed through Islamic financial instruments can further enhance this effect.

6.5. Encourage Public-Private Partnerships (PPPs)

Public-private partnerships can mobilize resources and expertise for green economic development. Facilitating partnerships between Islamic financial institutions, government bodies, and private sector entities can co-finance large-scale clean energy and green infrastructure projects, leveraging strengths from both sectors.

6.6. Monitor and Evaluate Market Dynamics

Continuous monitoring and evaluation of Islamic finance's impact on clean energy and green economic development are essential. Establishing mechanisms to track performance and make data-driven policy adjustments can ensure alignment with market conditions and sustainable development.

Implementing these policy recommendations can capitalize on the positive impacts of the Islamic stock market, fostering a sustainable and prosperous future for the Asia-Pacific region.

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