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Article

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Asymmetric Effect of Renewable Energy Generation and Clean Energy on Green Economy Stock Price: A Nonlinear ARDL Approach

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ABSTRACT

This paper examines the asymmetric impact renewable energy generation and clean energy prices on green economy stock prices by employing monthly data for all three indices end on 2021M07, and start on 2010M12. The nonlinear ARDL approach (NARDL) is applied in order to find short-run and long-run asymmetries. The empirical results indicate that renewable energy generation significant negative impact on green economy stock prices. For the clean energy prices have a positive and negative significant impact on green economy stock prices in selected markets under concern. The short-run coefficients of clean energy stock prices have a significant positive affect on green economy stock prices. The Wald test results confirmed the green economy stock price adjustment is running towards the long- and short-run steady increment regarding positive and negative shocks in renewable energy generation and clean energy. Finally, the dynamic multipliers showed that prices of renewable energy generation have a positive (negative) impact on green economy stock prices. Indeed, clean energy prices respond quickly to the changes (both positive and negative) on green economy prices in all selected markets. In sum, the negative shocks dominate positive shocks in renewable energy generation and clean energy, and results indicate that a positive and negative relationship was noted between these covariates and green economy stock prices.

Keywords: Renewable Energy, Clean Energy, Green Economy, Asymmetric Analysis, Nonlinear ARDL
JEL Classifications: F47, G15, G17, Q20, Q40,

1. INTRODUCTION

The green economy is an alternative vision for growth and development; one that can generate economic development and improvements in people's lives in ways consistent with advancing also environmental and social well-being. Over the last decade, a frequent claim has been that the traditional economic models need to be reformed in order to address climate change, biodiversity losses, water scarcity, etc., while at the same time addressing key social and economic challenges.

Today, renewable energy resources have become increasingly more important due to the fact that they have fewer negative impacts on the environment than other sources of energies and the growing limitations of fossil fuels. Its consumption contributed to about 22% of the World's final energy consumption by 2015 (Balsalobre-Lorente et al., 2018). Due to the comprehensive benefits of using renewable energy, the global demand for renewable energy is predicted to rise to 31% by 2035 (Sieminski, 2016). On the same side, developed and developing countries are in advance to increase renewable energy generation. For instance, in the United States (US) renewable energy resources are planned to generate enough clean energy and electricity in the next two decades (Khoie et al., 2019). On other hand, the new directive establishes a new renewable energy target for the Europen Union (EU) in 2030 of at least 32% and is binding for all members.

According to the European Environment Agency, in the EU the share of energy from renewable sources reached 18.0% of gross final EU energy use in 2018, compared to only 8.5% in 2004 (Smolovic et al., 2020). In Asia, renewables and green economy development continued to rise and proved resilient throughout the pandemic. Technological developments concerning energy islands, battery storage, floating wind, and hydrogen could also help advance the low-carbon transition. These developments across the region demonstrate that Asia is generally on track to achieve most of its renewable energy targets. However, the pace of the region's energy transition is nowhere near fast enough to deliver on the Paris Accord. Asia and the rest of the world still need to transition faster (Zhang and Nguyen, 2021).

There has been a global call for renewable energy generation in all the world for the last decade, especially the most energy-consuming and generation ones found in Asia, the EU, and the US, as a way of supporting green growth (Nguyen and Kakinaka, 2019; Brodny and Tutak, 2020). The projections about the depletion of fossil fuels globally and the new quest to move to a green energy consumption and eneration provide the impetus for actions to mitigate the harmful effects on the climate (Maji et al., 2019). With the increased use of renewable energy, there has been an extensive number of empirical literatures that examined the causal relationship between renewable energy consumption and economic growth indeveloped and developing countries. However, large gaps in the literature remain. There is very limited empirical evidence for the asymmetric effects of renewable energy generation and clean energy on green economy. The aim of this paper is to fill these important gaps in the literature.

Recently, some scholars focused on the investigation of the relationship between renewable energy consumption, economic growth, and sustainable development. For instance, Qudrat-Ullah and Nevo (2021) found that, the environmental sustainability through a reduction of emissions may not be towards achieving an all-inclusive development for Africa. On other hand, provides empirical support to the important role of economic growth and non-renewable energy prices in the renewable energy transition in Europe (Li and Leung, 2021). Furthermore, Sadorsky (2009) and Silva et al. (2018) found there was a positive effect of economic growth on renewable energy consumption in emerging countries. On the contrast, Dogan et al. (2016) demonstrated that the economic growth negatively impacted the renewable energy consumption in Turkey. Moreover, Nguyen and Kakinaka (2019) found that renewable energy consumption was positively linked with economic growth for high-income countries and negatively for low-income countries. Likewise, Razmi et al. (2020) highlighted the economics growth rate significantly affects total hydropower, wind, solar, and nuclear energies in both the short and long run, although it is only significant in the short run for combustible renewable and waste energies in Iran. Alam and Murad (2020) found that economic growth positively affected renewable energy consumption in the long term, but negatively in the short run in OECD countries. Rahman and Velayutham (2020) stated that there existed a unidirectional causality from economic growth to renewable energy consumption in South Asia. However, bidirectional causality between renewable energy consumption and economic growth was accured by Apergis and Payne (2020), Belaïd and Zrelli (2019).

This paper differs from other empirical research on this issue as most papers in this field of study renewable enery generation and clean energy prices on green economy stock prices by monthly data. For our research objective, we make three key contributions. First, financial markets, especially the renewable energy markets, can help developing green energy industries to raise and circulate capital within the broader economic system. While, a mentioned above, some empirical studies have examined the relationship between energy consumption and economic growth with nonrenewable and renewable energies, there is a gap in research pertaining to the relationship between renewable energy and green economy stock prices. The study covers this gap by focusing on renewable energy markets that have largely been ignored in prior research. Second, we argue that analyses of the relationship between the variables in a nonlinear setting have atleast two important reasons: (1) (a) timeseries can have hidden cointegration if positive and negative components of a series are cointegrated (Granger and Yoon, 2002) and (b) asymmetry is types of nonlinearities that affect the market dynamics, especially when the sample period is marked with the pre-and post-pandemic. To achieve these purposes, we employ the Nonlinear Autoregressive Distributed Lag (NARDL) approach proposed by Shin et al. (2014) which all owstesting the long-run and short-run asymmetries. Moreover, unlike the standard cointegration techniques, this method permits timeseries to have different orders of integration (Shin et al., 2014). Third, studies on renewable energy markets usually use one type of renewable energy price, while this paper compares two renewable energy industries: stock prices of renewable energy generation and clean energy, and we examine their asymmetric effects on the green economy stock price. This type of analysis has the potential to support future policy recommendations. Indeed, this study uses the indices of the renewable energy markets of Asia, Europe, and the US.

The remainder of this paper is organized as follows. Section 2 presents a literature review on the causal nexus between renewable energy and sustainable economic growth. Section 3 presents the data and the descriptive statistics. Section 4 introduces the empirical methods, including model specifications. In section 5, we report and analyze the empirical results and discussion. Finally, section 6 presents the paper's conclusions and policy implications.

2. LITERATURE REVIEW

In the existing empirical literature, the causal nexus between renewable energy and sustainable economic growth has significantly attracted energy scholars and policymakers worldwide. Indeed, many studies have explored this relationship by using three different types of data horizons: panel, time-series, and cross-country analyses.

Guo et al., (2021) have investigated asymmetric between oil prices and renewable energy consumption in the G7 countries. They found that, except for France and Germany, the oil prices of other countries have a significant asymmetric effect on renewable energy consumption, but there is great heterogeneity between the countries. Similarly, by using a non-linear autoregressive distributed lagged model Namahoro et al., (2021) examined asymmetric nexus of renewable energy consumption and economic growth in Rwanda. The authors' results shows that, renewable energy consumption affects economic growth. Also, asymmetric causality relationship, which is running from positive effecects renewable energy consumption to economic growth is noted. Furthermore, the unidirectional causality effect flowing from both agriculture and capital to economic growth for both positive and negative shocks is obtained.

Moreover, using the dynamic ordinary least squares and heterogeneous non-causality approaches Shahbaz et al., (2020) have investogated the effect of renewable energy consumption on economic growth across 38 renewable-energy-consuming countries. They found that, the presence of a long-run relationship between renewable energy consumption and economic growth. Authors suggest that governments, energy organization and companies, and also associated bodies must act together in increasing renewable energy investment for low carbon growth in economies under concern.

Chen et al., (2020) have examines the relationship between renewable energy and economic growth by employing a threshold model. They results demonstrated that the effect of renewable energy consumption on economic growth is positive and significant if and only if developing countries or non-OECD countries surpass a certain threshold of renewable energy consumption. In the paper, authors suggested that for developing countries to realize positive economic growth from their investment to renewable energy, they need to surpass a certain threshold of renewable energy consumption. Likewise, Wang and Wang (2020) found that the effect of renewable energy consumption on economic growth is positive, which indicates that increased renewable energy consumpiotn contributes to economic growth in OECD countries. In addition, this positive relationship changes as the threshold value changes, which means that the role of increasing renewable energy consumption to promote economic development is nonlinear.

Furthermore, Salari et al., (2021) have investigated the causal nexus between economic growth and energy consumption for the US. The authors applied four known hypotheses are: growth conservative, feedback, and neutral, differentiating between renewable and non-renewable energy consumption. Results for renewable energy, industrial energy, and residential energy consumption showed more support for the growth hypothesis. Their results have policy implications in terms of optimizing decisions and investments to efficiently improve economic growth while reducing energy consumption.

More recently, Li and Leung (2021) evaluated the renewable energy-economic growth nexus in seven European countries for the period of 1985-2018. In the study, long-run causality is found to flow from all explanatory variables to renewable energy consumption. Short-run causality is also detected from the two fossil fuel prices to renewable energy consumption. Authrors provides empirical support to the important role of economic growth and non-renewable energy prices in the renewable energy transition. Their findings showed that there are no evidence of Granger causality from renewable energy consumption to economic growth.

3. DATA AND DESCRIPTIVE STATISTICS

We rely on the three most widely used stock indices in the renewable energy sector to represent the renewable energy market. First, we use the world Renewable Energy Generation (GRNREG). This index is a primary sector index of the Green Economy Index designed to track companies that produce energy through renewable sources such as solar, wind, geothermal, wave, and fuel cells. Second, we chose the Clean Energy Focused Asia, Europe and U.S (GRNFOCAS, GRNFOCEUR, GRNFOCUS). This index is designed to track the sectors of the Green Economy specifically enabling the advancement of energy generation via non-fossil based sources. Also, index involves of the following sectors: Renewable Energy, Energy Efficiency, Advanced Materials, and Bio/Clean Fuels. Finally, we chose the Index of Green Economy for Asia, Europe and U.S (GRNASIA, GRNEUROPE, GRNEXUS). This index is is a market-capitalization weighted designed to track the performance of companies across the spectrum of industries most closely associated with the economic model around sustainable development through every economic sector. The Green Economy Index includes companies involved with industries such as Energy Efficiency, Renewable Energy Generation, Advanced Materials, Green Building, and Healthy Living. The Index is designed to serve as a global benchmark of all companies involved in the reduction of fossil-sourced fuels, products, services, and lifestyles of companies domiciled in the Asia, Europe and U.S. The monthly sample periods for all three indices end on 2021M07, and start on 2010M12. We retrieve the data on these renewable energy stock indices from the Nasdaq Global Indexes.

Table 1 reports the descriptive statistics for stock prices of renewable energy generation, clean energy and green economy over the entire period. According to the table entries, the averages of monthly series are smaller than their computed standard deviations in all cases. From Table 1, we can see that the U.S. and Asia have the high and low mean GEC. Then, we compare the maximum and minimum values of GEC in selected markets and found that the min and max value of selected markets are similar, but the maximum value of GEC (U.S.) is higher than that of other markets under study, which means that U.S. attaches great importance to the development of green economy and clean energy.

In addition, we observe that the standard deviation of GEC is less than the standard deviation of other selected series under study. This implies that green economy is more profitable and less risky than renewable energy generation and clean energy over the study period. The skewness and kurtosis of the selected series are significant. Lastly, for the sample size considered in this paper, the selected variables under study seems to be conditionally heteroskedastic.

Since the meaningful nonlinear framework necessitates the stationarity of all series under concern, we initially test for a unit

Table 1: Descriptive statistics for selected variables

Variable	Mean	Max.	Min.	St. Dev.	Skewness	Kurtosis	J-B
Asia							
REG	7.1144	8.0992	6.3274	0.4242	0.3807	2.7980	3.3105
CEP	6.5032	7.0758	5.9213	0.2450	−0.1631	2.8749	0.6513
GEC	6.8963	7.2463	6.5048	0.1688	−0.4229	2.7471	4.1564
Europe							
REG	7.1144	8.0992	6.3274	0.4242	0.3807	2.7980	3.3105
CEP	6.9844	7.6332	6.4279	0.2607	0.5268	3.6709	8.3231
GEC	7.0932	7.6082	6.6594	0.1974	0.4442	3.6726	6.6240
U.S							
REG	7.1144	8.0992	6.3274	0.4242	0.3807	2.7980	3.3105
CEP	7.2850	8.1248	6.6550	0.3875	0.4252	2.0857	8.3163
GEC	7.3435	8.3097	6.7202	0.3798	0.8166	3.1708	14.3845

Here, REG, CEP and GEC represent log changes of renewable energy generation, clean energy and green economy stock prices, respectively

Table 2: Results of unit root tests

Variable	ADF	1st Diff.	PP	1st Diff.	KPSS	1st Diff.
	Level		Level		Level	
Asia						
REG	−10.356	−10.356***	−2.2572	−10.352***	0.2054***	0.0613
CEP	−2.7066	−9.1221***	−2.4215	−9.1221***	0.0751***	0.0794
GEC	−2.4525	−9.5668***	−2.2424	−9.4807***	0.1530***	0.0853
Europe						
REG	−10.356	−10.356***	−2.2572	−10.352***	0.2054***	0.0613
CEP	−1.8835	−10.424***	−1.8835	−10.404***	0.1192***	0.0495
GEC	−2.1169	−10.707**	−2.1853	−10.777***	0.0974***	0.0649
US						
REG	−10.356	−10.356***	−2.2572	−10.352***	0.2054***	0.0613
CEP	−2.6499	−12.416***	−2.4769	−12.716***	0.2014***	0.0557
GEC	−1.4217	−11.960***	−1.3633	−12.063***	0.2054***	0.0613

***, **, *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

root tests by using conventional augmented Dickey-Fuller (ADF), Phillips–Perron (PP) and the Kwiatkowski–Phillips–Schmidt–Shin (KPSS) tests for the series under study. The results summarized in Table 2 suggest that all examined variables are non-stationary in levels while they become stationary when their first difference (with intercept and trend) form is used. It is worth noting that when the variables are at least integrated of order one i.e. I(I), the NARDL technique gives the fair results compared to the other cointegration techniques (Fousekis et al., 2016). Therefore, we can proceed with testing of cointegration in a nonlinear framework.

The existence of long-run asymmetric relationship stock prices of renewable energy generation, clean energy and green economy is ascertained using the bound testing procedure on 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 long-run relationship between selected variables concern.

4. EMPIRICAL METHODOLOGY

We employ the nonlinear autoregressive distributed lag (NARDL) model to examine long-run and short-run asymmetric effects of renewable energy generation and clean energy prices on green economy stock price. The noninear ARDL (hereafter, NARDL) approach proposed by Shin et al. (2014) which all owstesting the long-run and short-run asymmetries. NARDL approach provides robust empirical results even for the small sampel sizes (Chatak and Siddiki, 2001; Narayan and Narayan, 2007; Pesaran et al., 2001) and can be applied regardless of the order of integration with the exception that the series is integrated with the maximum order of one. The order of integration can be verified using unit root tests. Indeed, when the time series are noted to have cointegration using their positive and negative components (Granger and Yoon, 2002), the case of nonlinear cointegration is implied.

Table 3: Bounds tests for nonlinear specification

Dependent variable	$FPSS_{Nonlinear}$	t_{BDM}
Asia		
GEC	5.4917***	−4.9975***
Europe		
GEC	4.1537***	−4.2559***
US		
GEC	3.1226***	−2.2082***

Here, REG, CEP and GEC represent log changes of renewable generation, clean energy and green economy stock prices, 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

4.1. Nonlinear Autoregressive Distributed Lag (NARDL) Model

The NARDL approach allows modeling asymmetric cointegration using positive and negative parial sum decompositions and detecting the asymmetric affects both in the short- and long-run. It also allows te joint analysis of the issues of non-stationarity and nonliearity in the context of an unrestricted error correction model. The nonlinear cointegration regression (Shin et al., 2014) is specified as follows:

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

were β^+ and β^- are long term parametres of k×1 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:

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

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

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:

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

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

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:

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

where as h=∞, 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.

5. EMPIRICAL RESULTS AND DISCUSSION

Throughout this section, the empirical results from model estimation will be exhaustively discussed. As mentioned in our introduction, our main objective is to examine asymmetric effects of renewable energy generation and clean energy on green economy: the case of Asia, Europe and U.S renewable energy markets. We employ NARDL model to examine long-run and short-run asymmetric effects of renewable energy generation and clean energy on green economy stock prices. For the NARDL method, we obtain the asymmetric cumulative dynamic multiplier effects of renewable energy generation and clean energy on green economy stock prices, as well as the characteristics of symmetry or asymmetry in the short and long term. Finally, we apply the cumulative sum (CUSUM) and cumulative sum of squares (CUSUMQ) of the recursive residuals to test the robustness (Brown et al., 1975).

After confirmation of cointegration among the variables, we proceed with the results of long-run and short-run asymmentric impact of reneable energy generation and clean energy on green economy stock prices. The results summarized in the following panel of Table 4 shows that rebewable nergy generation siginicant negative impact on green economy stock prices in Asian and European merkets (except U.S market). However, renewable energy generation significant positive effected on green economy stock prices at U.S market. For the clean egergy prices have a positive and negative significat impact on green economy stock prices of Asian and Europen merkets. However, clean energy stock prices have a significant negative effect on green economy stock prices in U.S market.

The short-run dynamics are reported in the lower panel of Table 5. Our finding summarized the short-run coefficients of clean energy stock prices have a significant positive affect on green economy stock prices under the selected Asian, European and U.S markets. Change in renewable energy generation stock prices have a negatively insignificant impacts on Asian and European green economy stock prices. However, short-run coeffficients of renewable energy geration negatively and positively impacted on green economy stock prices of U.S market.

In addition, we applied the Wald test to verify the suitability of a nonlinear model (Table 6). Wald tests reject the null hypothesis of long-run and short-run symmetry of positive and negative

Table 4: Long-run coefficient estimates of NARDL Model

Market	Variable	Coefficient	Probability
Asia	LENGEN_POS	0.115889	0.3225
	LENGEN_NEG	−0.455175	0.0000
	LCENER_POS	0.406396	0.0002
	LCENER_NEG	0.716064	0.0000
	C	6.890467	0.0000
Europe	LENGEN_POS	−0.178242	0.3439
	LENGEN_NEG	−0.361246	0.0287
	LCENER_POS	0.854498	0.0001
	LCENER_NEG	0.927137	0.0000
	C	6.965981	0.0000
U.S	LENGEN_POS	0.779959	0.0301
	LENGEN_NEG	−0.610046	0.3943
	LCENER_POS	−0.031126	0.9235
	LCENER_NEG	0.978806	0.0324
	C	7.002956	0.0000

Here, LENGEN and LCENER represent of renewable generation and clean energy stock prices, respectively

Table 5: Short-run coefficient estimates of NARDL Model

Market	Variable	Coefficient	Probability
Asia	C	−0.001098	0.8085
	DLENGEN_POS	0.090761	0.3983
	DLENGEN_POS(−1)	−0.070511	0.3318
	DLENGEN_NEG	0.228950	0.0442
	DLCENER_POS	0.436978	0.0000
	DLCENER_NEG	0.524320	0.0000
	ECT(−1)	−0.266205	0.0000
Europe	C	7.37E-05	0.9759
	DLENGEN_POS	−0.073208	0.3856
	DLENGEN_NEG	0.037118	0.6848
	DLCENER_POS	0.769238	0.0000
	DLCENER_NEG	0.863344	0.0000
	ECT(−1)	−0.185497	0.0000
U.S	C	−0.001427	0.6623
	DLCENER_POS	0.743864	0.0000
	DLCENER_NEG	0.934801	0.0000
	DLCENER_NEG(−1)	0.131086	0.1278
	DLENGEN_POS	0.160487	0.0180
	DLENGEN_POS(−1)	0.172047	0.0013
	DLENGEN_NEG	0.045906	0.5238
	DLENGEN_NEG(−1)	−0.244433	0.0009
	ECT(−1)	−0.049783	0.0004

Here, DLENGEN and DLCENER represent of renewable generation and clean energy stock prices, respectively. ECM (-1) is the error correction term, that is, the residual with a one period lag, respectively

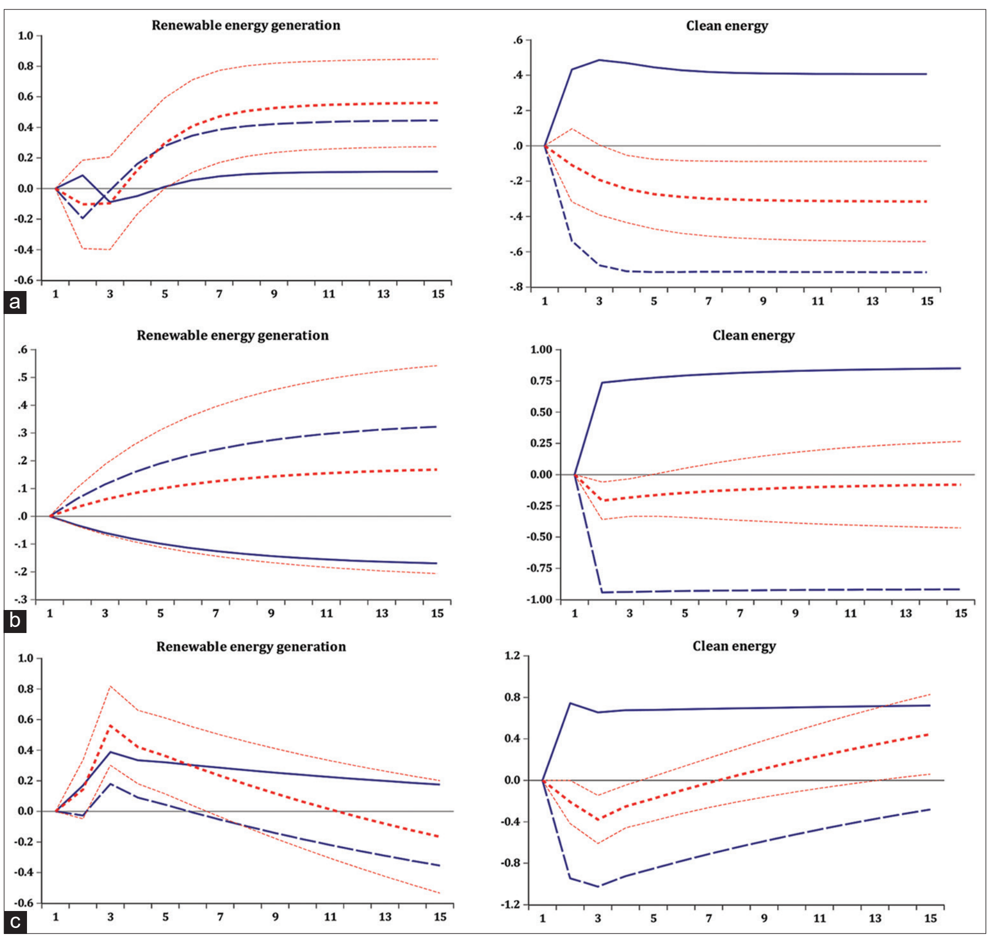
components of all examined variables. They show that the green economy stock price adjustment is running towards the long- and short-run steady increment regarding positive and negative shocks in renewable energy generation and clean energy. These indicate the inequality effect of long- and short-term covariates on green economy in various lengths of time. What we understand about the shocks of the clean energy price on green economy stock prices

Table 6: Wald test for long-run and short-run

Market	Variable	Long-run (coefficients)	Short-run (coefficients)
Asia	LENGEN_POS	0.9587	0.8967
	LENGEN_NEG	−3.3857***	2.0344**
	LCENER_POS	3.1066***	5.6298***
	LCENER_NEG	4.3204***	6.9164***
Europe	LENGEN_POS	−0.9258	−0.8708
	LENGEN_NEG	−1.8471*	0.4069
	LCENER_POS	2.9067***	8.8025***
	LCENER_NEG	3.1566***	9.8907***
US	LENGEN_POS	−0.0977	4.1564***
	LENGEN_NEG	2.7918***	−1.9816**
	LCENER_POS	1.8003*	9.6810***
	LCENER_NEG	−1.0556	9.1853***

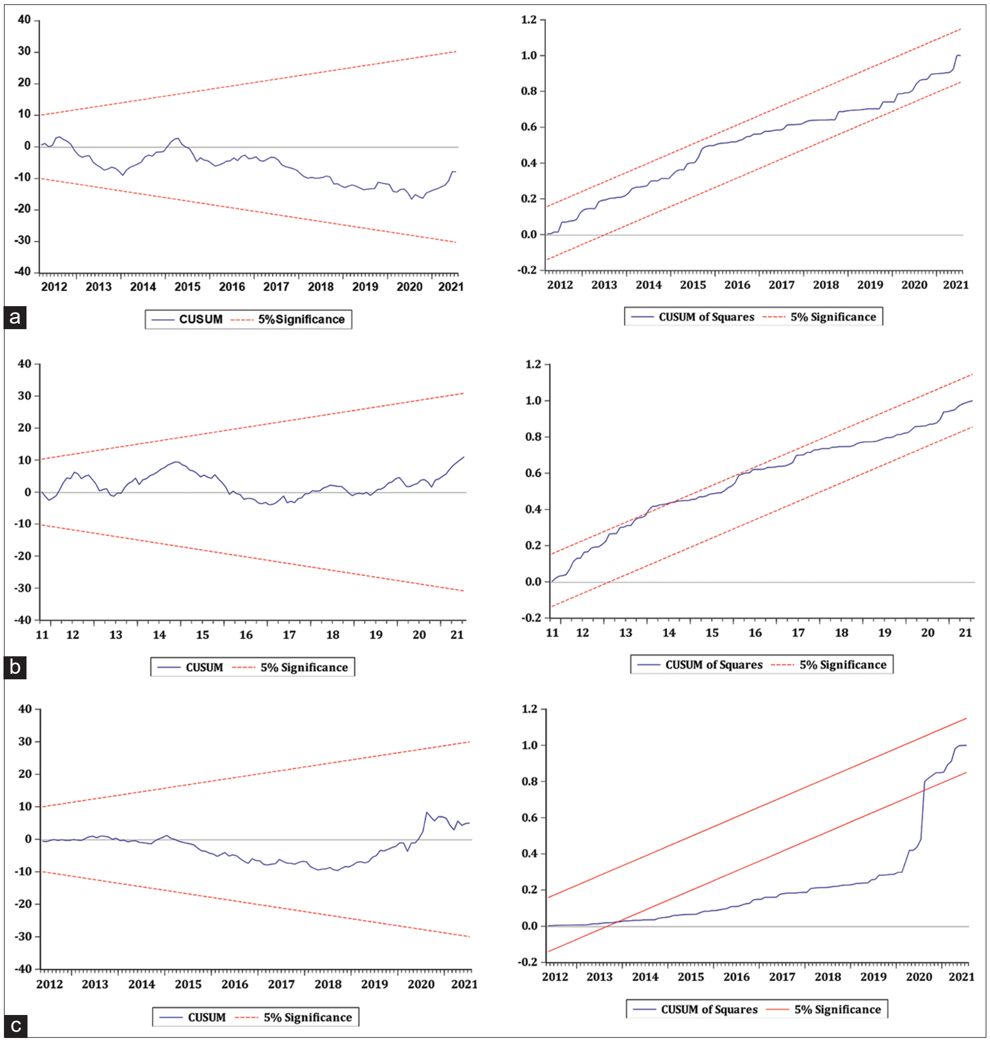
Here, LENGEN and LCENER represent of renewable generation and clean energy stock prices. ***, **, * indicate 1%, 5% and 10% significance level, respectively

Figure 1: Multiple plots that are showing the cumulative effect of renewable energy generation and clean energy on green economy stock prices long-run and short-run asymmetries. (a) Green economy (Asia), (b) Green economy (Europe) (c) Green economy (U.S). Note: Blueline shows the positive and blue(dotted)line is negative impact while red lines show asymmetry and confidence (upper and lower) bands.



Blueline shows the positive and blue(dotted)line is negative impact while red lines show asymmetry and confidence (upper and lower) bands

Figure 2: Stability tests of NARDL model (a) Green economy (Asia) (b) Green economy (Europe) (c) Green economy (U.S)



Asian, European and U.S markets are positively asymmetric in the short-run and long-run; coefficients of renewable energy generation have a the impact in the Asian and European green economy stock prices are negatively asymmetric in the long terms, and short terms in only U.S economy stock price. The increase in renewable energy generation prices may results in an increase in cost of egergy generation, which reduse the firm' profitability and finally decreases the stock prices in long-run. It shoud be noted that, Zhao et al. (2016) and Sim and Zhou (2015) found that, the energy shocks towards the fluctuations in output and inflation, reduce real consumption and thereafter effect the profitable of companies.

Furthermore, the dynamic asymmetric relationship between given variables are further enriched by plotting the multipliers effects. These multipliers (Figure 1) show the cumulative effect of renewable energy generation and clean energy on green economy stock prices long-run and short-run asymmetries. The linear combinations of multiple plots corresponding to the positive (blue line) and negative (dashed blue line) changes are presented through asymmetry curves. The overall long-run and short-run asymmetries in the positive and negative is presented through dashed red lines and corresponding upper and lower bounds of asymmetry (at 95% confidence level) are plotted using dotted red lines.

The dynamic multipliers show that prices of renewable energy generation (Figure 1) have a positive (negative) impact on green economy stock prices in Asian and European stock markets. However, renewable energy generation has a negative impact on green economy stock prices in the U.S market. The multiplier graphs show that the positive effects of renewable energy generation prices are greater than the negative effect.

Notably, clean energy prices respond quickly to the changes (both positive and negative) on green economy prices in all markets. However, the negative shocks dominate positive shocks in renewable energy generation and clean energy, and results indicate that a positive and negative relationship was noted between these covariates and green economy stock prices. Furthermore, Figure 2 also approves nonlinearity and model parameters stability, which shows that the NARDL model is appropriate for renewable energy generation, clean energy, and green economy in this study.

6. CONCLUSION

A mentioned above, some empirical studies have examined the relationship between energy consumption and economic growth with nonrenewable and renewable energies, there is a gap in research pertaining to the relationship between renewable energy and green economy stock prices. The study covers this gap by focusing on renewable energy markets that have largely been ignored in prior research. The Non-linear Autoregressive Distributed Lagged model (NARDL), which is suitable to examine long-run and short-run relationships between variables have been employed in this study to establish the asymmetric impact of renewable energy and clean energy on green economy stock prices.

Our empirical results confirmed a strong asymmetric co-integration relationship among selected variables under concen. The results summarized that rebewable nergy generation siginicant negative impact on green economy stock prices in Asian and European merkets (except U.S market). For the clean egergy prices have a positive and negative significat impact on green economy stock prices of Asian and Europen merkets (negative effect for U.S market). Furthermore, findings from short-run coefficients of clean energy stock prices have a positive affect on green economy stock prices under the selected Asian, European and U.S markets. Change in renewable energy generation stock prices have a negatively insignificant impacts on Asian and European green economy stock prices., short-run coeffficients of renewable energy geration negatively and positively impacted on green economy stock prices of U.S market. In addition, the wald tests results shows that the green economy stock price adjustment is running towards the long- and short-run steady increment regarding positive and negative shocks in renewable energy generation and clean energy.

Finally, multipliers shows the cumulative effect of renewable energy generation and clean energy on green economy stock prices long-run and short-run asymmetries. The dynamic multipliers confirmed that prices of renewable energy generation have a positive (negative) impact on green economy stock prices in Asian and European stock markets. However, renewable energy generation has a negative impact on green economy stock prices in the U.S market. The multiplier graphs show that the positive effects of renewable energy generation prices are greater than the negative effect. Indeed, clean energy prices respond quickly to the changes (both positive and negative) on green economy prices in all markets. In sum, the negative shocks dominate positive shocks in renewable energy generation and clean energy, and results indicate that a positive and negative relationship was noted between these covariates and green economy stock prices.

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