




Stock markets dynamics and environmental pollution: emerging issues and policy options in Asia

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Abstract

The fact is the stock market has an asymmetric effect on macroeconomic variables. In this study, we examine the nonlinear stock market reaction to the environment. This is the first study that considers the possibility of asymmetric effects of stock market on environmental pollution in Asia. This study considers the experiences of Asia economies by using the panel NARDL methodology over the data period from 1995 to 2019. The long-run panel NARDL results showed that the positive change in stock market increases carbon emissions. In adverse, the negative change in stock market significantly mitigates the carbon emissions in Asia. The short-run stock market asymmetric effects continued into the long-run asymmetric effects on the environment in Asia. Thus, policymakers and authorities should initiate to promote green financial activities in Asian stock markets.

Keywords CO2 emissions · Stock market · Asia economies

Introduction

The CO2 emissions are considered as the most important issues that are faced by Asian economies. Therefore, the identification of predictors of carbon emissions has received extensive consideration among researchers and policymakers as it supports them in formulating suitable policies related to energy and environmental pollution. A wide range of literature has investigated the effect of carbon emissions by including certain indicators, for example, energy consumption

(Bloch et al. 2015), economic growth (Narayan et al. 2016), trade openness (Sbia et al. 2014), financial development (Li et al. 2021b), industrialization (Ullah et al. 2020), and urbanization (Rafiq et al. 2016). The effect of stock market development on environmental pollution has been received much attention in the literature in the last few decades (Paramati et al. 2017; Ullah and Ozturk 2020).

The stock market development exerts an effect on carbon emission through different channels. The most dominant channel among them is business expansion. Developments of stock markets are predominantly appealing to economic activities. Sadorsky (2011) stated that substantial development of business contributes usually more to increasing carbon emissions due to more energy consumption. Furthermore, increasing activities of stock markets produce a wealth effect by disseminating risks for business enterprises and consumers that ultimately affect energy and environmental pollution (Mankiw and Scarth 2008). The development of the stock market is often measured as a dominant economic indicator, with better activities of the stock market being measured as a symbol of development and economic growth, which resultantly enhances both consumer and business confidence. Furthermore, Sadorsky (2011) stated that increasing economic confidence boosts the productivity of goods and services in the manufacturing sector, which leads to increased pollution emissions.

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Conversely, Lanoie and Roy (1997) noted that the developments of stock markets help in the reduction of environmental pollution by implementing strong actions and regulations on the enlisted enterprises/companies, so that they utilize greener technologies, which results in the reduction of industrial pollution and enhancement of energy consumption. Lanoie and Roy (1997) also stated that efficient stock markets compare and rank their enlisted firms according to their environmental performance that in turn inspires both smaller and larger polluters for the reduction in their levels of pollution emissions. Moreover, Paramati et al. (2018) added that stock markets increase sources of funding for investments in projects related to clean energy that results in reducing carbon pollution. Kutan et al. (2017) study also highlighted the same findings that an efficient and well-developed stock market conveys supplemental capital to the renewable energy sector. Due to these reasons, developments of stock markets exert a significant influence on the quality of the environment.

The stock market development is considered a key economic variable, and the increase in stock value is viewed as an indication of future economic development. The increased economic activity leads to increase energy demand. For a panel of 22 emerging countries, Sadorsky (2010) investigates the link between energy consumption and financial development. The study reports that in emerging economies, the development of the stock market exerts a positive and significant effect on energy demand and also increased CO₂ emissions. Sadorsky (2011) also investigates the nexus between energy consumption and financial development for a panel of nine frontier economies of Central and Eastern Europe by employing generalized methods of moments estimation. The study concludes that the development of the stock market exerts a statistically significant positive influence on energy consumption. In case of China, Zhang et al. (2011) investigated the impact of financial development on pollution emissions by employing time series analysis approach. The findings show stock market of China exerts a comparatively larger impact on pollution emissions; however, the impact of its efficiency is relatively smaller. On the other hand, Tamazian et al.'s (2009) study find that the development of stock market is negatively associated with pollution emissions. He and Liu (2018) empirically investigate the "Environmental Kuznets Curve (EKC) hypothesis" in the perspective of stock market developments and found the inverted U-shaped relationship between stock market development and carbon emission. Tamazian et al. (2009) use stock market values added as a proxy for measuring financial development in panel framework and examine their effect on the quality of the environment. Thus, empirical literature concludes that stock market has a positive or negative impact on the environment.

The present empirical literature on the CO₂ emissions of developed and developing economies has been explored the

influence of stock market as environmental pollution. For instance, a bulk of empirical studies considered stock market as the key source for CO₂ emissions for different economy and regions. for instance, Paramati et al. (2017) for developed and emerging market, Zafar et al. (2019) for G-7 and N-11 countries, Paramati et al. (2017) for G20 countries, and Gupta and Goldar (2005) for India. The above-listed empirical studies have used linear models to explore the nexus between stock market and environment. But these studies are not following any theoretical framework for empirical validation of their models. Although Ullah and Ozturk (2020) observe that the stock market's financial activities have an asymmetric effect on Pakistan's environments, this study only considers the Pakistan economy. The previous empirical literature has been provided the mixed results. Previous studies include a very limited number of economies for analysis. Previous work is neglecting the dynamic role of stock market in environment, while our study is capturing the dynamic behavior of stock market via an asymmetric ARDL approach.

This study also uses some robust panel econometric techniques that take into account cross-sectional dependence and heterogeneity in the analysis. Therefore, the analysis of this study provides more robust and reliable outcomes. This study provides better insights for policymakers and authorities. This is one of the first-panel studies of Asian economies that explore the dynamic impacts of stock market on environmental pollution in Asian countries by using the nonlinear ARDL econometric approach. In fact, the investigation of the nexus between stock market development and environmental pollution is very crucial for Asian countries in the formulation of policies and to rationally gauge the complications to combat environmental pollution. This is a pioneering study that offers an Asian regional analysis on the relationship between stock market development and environmental pollution. Our analysis provides positive and negative shock estimates of stock market development in analysis.

The rest of the study is structured as follows: the "Models and methods" section provides the model and methodology with data. The "Results and discussion" section covers the empirical results and discussion. Lastly, the "Conclusion and policy" section reports conclusions and policy.

This study raises the importance of environmental protection for other economies.

Literature review

In the last few decades, literature on energy economics has carried augmented demand functions of energy consumption that include social and economic variables into the basic model of energy. The nexus of greenhouse gases and economic growth is the twenty-first-century issue to debate among researchers and policymakers (Ozturk et al. 2021). Energy

innovation moderates the greenhouse gases for Organization for Economic Cooperation and Development (Baloch et al. 2021). Governance and institutional quality significantly affect the Asian stock markets (Ahmed et al. 2021). Financial development is among these variables referred to as the finance and growth theory (Hafeez et al. 2018; Rauf et al. 2018; Hafeez et al. 2019a). The literature on the issue of energy and growth has not been expanded yet; however, the studies on the issue are increasing steadily.

The theoretical background of finance and energy literature has been motivated by the hypothesis of finance-led growth (Hafeez et al. 2019a). However, past literature denoted that financial development can influence the demand for energy through three different channels. First, direct channel infers that consumers find cheaper and easier opportunities to borrow as the finance system improves to utilize durable goods that consume more energy. Second is the business channel, which infers that businessmen can find less costly and easy borrowing opportunities as the financial sector enhances that in turn influence demand of energy through production and investment decisions. The third is the wealth effect channel, which infers that the increase in financial activities can influence the confidence of economic agents by producing a wealth impact that can enhance energy demand and economic activity. As Sadorsky (2010) denoted that demand for energy could be irresponsible to the financial sector and validity of the hypothesis of finance-led growth, this association can be solved via empirical analyses.

In the previous literature, most of the studies have investigated the effect of financial development on the consumption of energy and measured financial development via the development of banking sector (see, for instance: Jalil and Feridun 2011; Ullah and Ozturk 2020; among others). Moreover, the fact is the stock market is considered one of the leading economic factors of economic growth. The stock market is highly effective for business activities (Sadorsky 2010), as it allows additional sources of finance for firms to increase their business. This helps investors and businesses diversify their risks, optimize capital structure, lower financing costs, and invest in new ventures (Paramati et al. 2017). This enlarged business activity is expected with a high demand for fossil fuel energy consumption, which in turn mitigates the environmental quality. Further, a stock market upsurges the income and wealth effect, which in turn affects environment (Mankiw and Scarth 2008). The stock market is often observed as the main source of prosperity and economic growth, which reinforces environmental pollution. Past many studies have also raised the importance of financial development on CO₂ emissions (Li et al. 2021b).

Over the last 2 decades, empirical studies have scrutinized the linkage between financial development of stock markets and CO₂ emissions around the globe. Studies conducted on developing, emerging, and developed economies showed that stock market has an effect differently on CO₂ emissions in

each group and results are inconclusive. The stock market of developed economies affects positively CO₂ emissions, whereas stock market of emerging and developing economies has a negative impact on CO₂ emissions (Younis et al. 2021). They reasoned that stock markets have articulated effective policies against pollution in developed economies, whereas stock markets have lagged in policies in emerging and developing economies. Dasgupta et al. (2006) studied that the stock market of developed economies has a negative impact on environmental quality in the USA and Canada. They also suggest that the USA and Canada can play a role in environmental quality by adopting environmental-friendly policies.

Empirical literature argues that stock market developments can substantially and robustly induce CO₂ emissions (Paramati et al. 2017; Zafar et al. 2019). The empirical literature reported two important channels of the stock market. Firstly, the stock market gives a new and alternate source of finance, which helps business sector in economy and thus raises environmental pollution. The second channel is based on the technology innovations that affect the environment positively (Paramati et al. 2017). Abbasi and Riaz (2016) scrutinize the role of the stock market on CO₂ emissions by using a time series data of Pakistan. The study shows that stock market developments significantly stimulate CO₂ emissions. Younis et al (2021) examine the impact of stock market on CO₂ for BRICS economies by using the GMM approach. Findings show that the stock market has a positive impact on CO₂ emissions in Brazil, whereas it has negative impact in China, India, Russia, and South Africa. They noted that the possible reason for the positive relationship between stock market and CO₂ is business expansion. Moreover, the stock market contributes to fossil fuel consumption which also upsurges environmental pollution.

There are a few empirical studies emphasized on stock market and CO₂ emissions nexus. For instance, Paramati et al. (2018) noted that the stock market has a positive and robust impact on CO₂ emissions in developing economies, whereas it has negative turns out in developed economies. Similarly, Zafar et al. (2019) tested the links between stock market and CO₂ emissions by using the data of N-11 and G-7 countries data spanning from 1990 to 2016. Findings show that stock market decreases environmental quality by increasing CO₂ emissions in G-7 countries while increases environmental quality by decreasing CO₂ emissions in N-11 countries. Overall, the significant empirical literature suggests that there are inadequate studies on the linkage between stock market and CO₂ emissions. Although, a limited number of studies address this issue for China, India, G-20, N-11, G-7, BRICS, develops economies, emerging economies, and developed economies. Previous studies have also found mixed and inclusive findings for the above-selected regions. Past studies have no address on this objective for Asian economies.

Unlike studies that have only found the linear relationship between stock market and CO2 emissions. Therefore, comparatively little effort has been delivered in investigating the impact of stock market variables on CO2 emissions (for instance, Tamazian et al. 2009; Paramati et al. 2017; Ullah and Ozturk (2020). Henceforth, our empirical study is designed to fill research gaps and offer new insights for authorities and policymakers.

Model and methods

A well-organized capital market plays an effective role in economic activities (Fama 1991). Numerous theoretical and empirical studies have dealt with different aspects of stock market and environment (Paramati et al. 2017 and Ulah et al. 2020). Generally, the financial system is a broader and multidimensional concept. However, the financial system consists of financial intermediaries (banks, pension funds, insurance activities) and financial markets (stock, bond, commodity markets, derivatives). A large share of an economy’s savings is mostly investments through the financial system. Thus an efficient financial system is a fundamental factor of environmental pollution and essential for an economy (Garcia and Liu 1999). This study based on Ullah and Ozturk (2020) empirical model and extended form is:

$$CO_{2,it} = \alpha_0 + \alpha_1 SM_{it} + \alpha_2 GDP_{it} + \alpha_3 FD_{it} + \alpha_4 EC_{it} + \mu_{it} \tag{1}$$

where $CO_{2,it}$ is the CO2 emissions and SM_{it} denotes the stock market for each country i ($i = 1, 2, \dots, N$) and over the time period t ($t = 1, 2, \dots, T$). While GDP per capita (GDP), financial development (FD), and energy consumption (EC) are used as a control variables, μ_{it} is error term. However, on the other hand, we first examine the stock market-CO2 nexus by assuming a linear response of stock market development to changes in CO2 in Asia. Similarly, stock market increased the economic activity in economy; hence, it will increase the environmental pollution with an estimate of α_1 which is expected to be positive. Stock market is the overall performance of economy; therefore, it raises the energy consumption level, and they robustly effect the environment. The linear model is:

$$\begin{aligned} \Delta CO_{2,it} = & \pi + \sum_{p=1}^{n1} \pi_{1p} \Delta CO_{2,it-p} + \sum_{p=0}^{n2} \pi_{2p} \Delta SM_{it-p} \\ & + \sum_{p=0}^{n3} \pi_{3p} \Delta GDP_{it-p} + \sum_{p=0}^{n4} \pi_{4p} \Delta FD_{it-p} \\ & + \sum_{p=0}^{n5} \pi_{5p} \Delta EC_{it-p} + \beta_1 CO_{2,it-1} + \beta_2 SM_{it-1} \\ & + \beta_3 GDP_{it-1} + \beta_4 FD_{it-1} + \beta_5 EC_{it-1} + \alpha_i \\ & + \mu_{it} \end{aligned} \tag{2}$$

For panel estimates, the long-run estimates are denoted by $\beta_1 - \beta_5$, and the short-run estimates are computed as $\pi_{1p} - \pi_{5p}$. Alternatively, the nonlinear panel ARDL model is an extension of linear ARDL model, and this is more famous in advanced time series, which are accounts for the positive and negative shocks in stock market. As the literature suggests that stock market has changed on the daily basis on bad and good news, it infers that stock market has an asymmetric effect on the environment. This phenomenon is only captured by NARDL approach. This means that the NARDL approach is a robust approach for the long- and short-run estimation and addressed the autocorrelation as well as endogeneity of the regressors. There are also three extra benefits of this approach. This method has its own tabulate values for the degree of integration in F-test and no need of pre-unit root testing due to macroeconomic variables. This approach is also to find out the panel short- and long-run estimates in one step, thus generating the two new time series variables as follows:

$$SM^+_{it} = \sum_{n=1}^t \Delta SM^+_{it} = \sum_{n=1}^t \max(\Delta SM^+_{it}, 0) \tag{3}$$

$$SM^-_{it} = \sum_{n=1}^t \Delta SM^-_{it} = \sum_{n=1}^t \min(\Delta SM^-_{it}, 0) \tag{4}$$

where SM^+_{it} measures the positive shock in stock market and SM^-_{it} measures the negative shock in stock market. We re-formulated linear panel ARDL Eq. (2) into a new error correction formats as follows:

$$\begin{aligned} \Delta CO_{2,it} = & \pi + \sum_{p=1}^{n1} \pi_{1p} \Delta CO_{2,it-p} + \sum_{p=0}^{n2} \pi_{2p} \Delta SM^+_{it-p} \\ & + \sum_{p=0}^{n3} \pi_{3p} \Delta SM^-_{it-p} + \sum_{p=0}^{n4} \pi_{4p} \Delta GDP_{it-p} \\ & + \sum_{p=0}^{n5} \pi_{5p} \Delta FD_{it-p} + \sum_{p=0}^{n6} \pi_{6p} \Delta EC_{it-p} \\ & + \beta_1 CO_{2,it-1} + \beta_2 SM^+_{it-1} + \beta_3 SM^-_{it-1} \\ & + \beta_4 GDP_{it-1} + \beta_5 FD_{it-1} + \beta_6 EC_{it-1} + \alpha_i \\ & + \mu_{it} \end{aligned} \tag{5}$$

Thus, the extended version of linear model is nonlinear version ARDL of Eq. (6). The nexus between stock market and CO2 emissions has been analyzed through a dynamic model. Therefore, we formulated a nonlinear panel ARDL model that is appropriate for large data period (T) and captured the dynamic panel heterogeneous. The pooled mean group (PMG) estimator offered by Pesaran et al. (1999) allows the intercept, short-run, and long-run coefficients. PMG estimator produces efficient and consistent estimates than MG estimator. In dynamic panels, to address the concern of heterogeneous slopes, Pesaran et al. (1999) incorporate the dynamic heterogeneous in panel model and estimated through the MG or PMG estimators. The MG estimator gives us the

short- and long-run parameters. This estimator has also added the intercepts that vary across groups.

Data

This study uses a balanced panel dataset of 26 Asian economies from 1995 to 2019. The sample countries from Asia are selected based on the data availability. The samples of Asian countries are as follows: Bangladesh, Indonesia, Saudi Arabia, Japan, Israel, Vietnam, Kazakhstan, Kuwait, India, Bahrain, Sri Lanka, Pakistan, United Arab Emirates, Iran, Islamic Rep, Cyprus, Qatar, Jordan, Lebanon, China, Oman, Singapore, Thailand, Philippines, Turkey, Malaysia, and Cambodia. Data on CO2 emissions, stock market, GDP per capita, financial development, and energy consumption are obtained from the World Bank. For best estimates, we have transformed the CO2, GDP, FD, and EC variables in natural logarithms forms. The detailed data definition and sources are reported in Table 1.

Results and discussion

The world has become a global village in the modern era, so cross-sectional dependence (CD) exists between the economies and regions. Pedroni (2004, Pedroni 2001) has found that the omitted common factor, residual interdependence, and spill-over partial impact are vital determinants of CD. Thus, the second-generation panel data models, for instance, panel unit root and cointegration estimates, are good enough to find the robust estimates in the existence of CD. Hence, to resolve this problem, this research employed the CD test as a primary gauge to explore the cross-sectional dependencies to proceed further with the panel unit root tests (Liu et al. 2018). CD test turns out are reported in Table 2. The results shown from the cross-sectional dependence test accept the alternative hypothesis and confirm independence among the panel series.

After inspecting the independence between the panel series, in the next step, we employed the various panel unit root test to investigate the integration order of all the incorporated variables. It is necessary to avoid spurious regression to check the stationary of a variable. Besides, the non-stationary may give unreliable results. To depict the variables' stationery, we

Table 2 Cross-sectional dependence test

Variable	CD test	P-value	Off-diagonal elements
CO2	12.14***	0.000	0.485
SM	14.81***	0.000	0.433
GDP	11.24***	0.000	0.490
EC	0.958	0.347	0.405
FD	14.69***	0.000	0.433

*** shows 1 percent significance level

employed various panel unit root tests such as Fisher-ADF and Levin-Lin-Chu (LLC) tests. The entire unit root test's null hypothesis indicates the existence of the unit root. The outcomes of the panel unit test are represented in Table 3 for each variable. To examine all the variables, e.g., CO2, SM, GDP, EC, and FD, at the lever and after taking the first difference. Most of the variable has an insignificant result at the level, and the results confirm the presence of unit root. Thus, after taking the first difference, the outcomes are significant and become stationary. Thus, we may apply panel ARDL estimates to find out the long- and short-run elasticities of coefficients.

After confirming the order of integration, we used symmetric and asymmetric ARDL to find both the short-run and long-run coefficients. Besides panel ARDL is also suitable in different integrated orders, I(1), I(0), and or a mixed order of integration. Table 4 highlights the panel ARDL and NARDL, both the long-run and short-run estimates. Panel A offered the long-run dynamics, while panel B indicate the short-run dynamics. However, panel C depicts the various diagnostic tests. The empirical results show that stock market development revealed an insignificant impact on carbon emission in the long run in the selected Asian economies. The turns out also indicate that a 1% increase in the stock market improvement contributes to carbon emissions 0.001% at the 10% significance in the short run in Asian economies. The outcome from ARDL suggests that an increase in the GDP growth contributes to carbon emission both in the long run and short run. Hence, the result indicates that a 1% increase in FD stimulates environmental pollution by approximately 0.527% at a 1% significance level. The EC has an insignificant impact on

Table 1 Variables definition and sources

Variable	Symbol	Measure	Source
Carbon dioxide emissions	CO ₂	CO ₂ emissions (kt)	WDI
Stock market	SM	Stocks traded, total value (percentage of GDP)	WDI
Gross domestic product	GDP	GDP per capita (constant 2010 US\$)	WDI
Financial development	FD	Domestic credit to private sector (percentage of GDP)	WDI
Energy consumption	EC	Energy use (kg of oil equivalent)	WDI

WDI World Development Indicators

Table 3 Unit root tests

	LLC I(0)	I(1)	Decision	ADF I(0)	I(1)	Decision
CO2	0.481	-9.689***	I(1)	5.161	-18.22***	I(1)
SM	-4.460***		I(0)	-5.516***		I(0)
GDP	0.645	-18.33***	I(1)	5.447	-10.80***	I(1)
EC	-4.429***		I(0)	1.214	-22.79***	I(1)
FD	2.496	-7.549***	I(1)	3.261	-16.37***	I(1)

the atmosphere in the short run. Further, the results demonstrate that a 1% increase in energy use and financial development enhances carbon emissions to about 0.392% and 0.555%, respectively, at a 1% level of significance in the long-run Asian economies.

Nonlinear ARDL turn out is offered in Table 4 in model 2. The results indicate that the positive part of stock market development has an insignificant impact on carbon emissions in the long run and in the short run. Moreover, results explored that the negative part of stock market development mitigated environmental pollution both in the short run and long run in Asian economies. The results showing a 1% decrease in the negative part of stock market efficiency lead to a decline in environmental pollution to about -0.002% at 1% significance level both in the short run and long run in Asian economies.

The empirical results indicate that a 1% increase in financial development contributes to carbon emissions to about

0.546% at a 1% level of significance in the long run in concerned Asian economies. Additionally, the results depict that increase in energy use is positively linked with pollution emissions. Most Asian countries depend on conventional energy sources, which is the primary reason for rising environmental pollution. The results are in the same line as Ahmed et al. (2019) and Ullah et al. (2020) in the case of Pakistan. Panel C elaborates statistical diagnostic tests. The outcome demonstrates that ECM and F-statistics values are significant and specifies the existence of the long-run relationships among the panel data series.

We check whether the results deviate from the basic panel ARDL or NARDL analysis. Therefore, the robust analysis is applied in Table 5. The results are similar and stable to the ARDL and NARDL estimates. Our results are robust at the different lag structures, and results improve the reliability and validity of the estimates. The nonlinear ARDL robustness

Table 4 Short- and long-run panel ARDL and NARDL

Variable	Coefficient	S.E	t-Stat	Prob.	Coefficient	S.E	t-Stat	Prob.
Long run								
SM	0.001	0.002	0.542	0.124				
SM_POS					0.001	0.001	0.095	0.924
SM_NEG					-0.002***	0.001	2.718	0.007
GDP	1.075***	0.066	16.37	0.000	0.930***	0.038	24.75	0.000
FD	0.392***	0.059	6.643	0.000	0.546***	0.073	7.527	0.000
EC	0.555***	0.048	11.46	0.000	0.572***	0.030	19.02	0.000
Short run								
D(SM)	0.001*	0.001	1.923	0.055				
D(SM_POS)					0.001	0.002	0.418	0.676
D(SM_NEG)					-0.002**	0.001	1.961	0.051
D(GDP)	0.610***	0.213	2.867	0.004	0.509**	0.205	2.478	0.014
D(FD)	0.527***	0.118	4.459	0.000	0.461***	0.126	3.655	0.000
D(EC)	0.052	0.078	0.664	0.507	0.011	0.122	0.090	0.929
C	-0.385**	0.157	2.450	0.015	-0.272	0.145	1.881	0.061
Diagnostic								
ECM	-0.057*	0.038	1.781	0.076	-0.045*	0.025	1.800	0.063
Log likelihood	1042.9				1041.0			
F-test	25.20***				29.09***			

Note: One asterisk, two asterisks, and three asterisks denote significance at 10%, 5%, and 1% levels, respectively

Table 5 Short- and long-run panel ARDL and NARDL (robust analysis)

	Coefficient	S.E	t-Stat	Prob.	Coefficient	S.E	t-Stat	Prob.
Long run								
SM	0.003***	0.000	7.416	0.000				
SM_POS					0.004***	0.000	9.448	0.000
SM_NEG					-0.005***	0.000	14.50	0.000
GDP	0.706***	0.094	7.513	0.000	2.338***	0.128	18.33	0.000
FD	1.457***	0.041	35.14	0.000	0.664***	0.067	9.872	0.000
EC	3.730***	0.166	22.47	0.000	0.928***	0.090	10.27	0.000
Short run								
D(SM)	0.002	0.002	1.025	0.307				
D(SM(-1))	-0.003	0.003	1.084	0.280				
D(SM(-2))	-0.001	0.002	0.595	0.553				
D(SM_POS)					0.002	0.003	0.669	0.504
D(SM_POS(-1))					0.011**	0.006	2.012	0.045
D(SM_NEG)					0.003	0.003	0.987	0.325
D(SM_NEG(-1))					-0.005**	0.002	-2.270	0.024
D(GDP)	0.997**	0.435	2.289	0.023	0.853**	0.397	2.147	0.033
D(GDP(-1))	-0.642	0.451	1.425	0.156	-0.419	0.286	-1.466	0.144
D(FD)	0.498**	0.257	1.938	0.054	0.444***	0.158	2.810	0.005
D(FD(-1))	-0.037	0.164	0.228	0.820	-0.096	0.182	-0.526	0.599
D(EC)	-0.116	0.203	0.571	0.569	-0.036	0.119	-0.305	0.761
D(EC(-1))	-0.063	0.198	0.320	0.749	-0.210*	0.114	-1.841	0.067
C	-0.384	0.287	1.337	0.183	-0.777	0.618	-1.257	0.210
Diagnostic								
ECM	-0.057*	0.032	1.781	0.076	-0.045*	0.026	1.730	0.079
Log likelihood	1532.1***				1309.1***			
F-test	24.11***				23.55***			
Number of county	26				26			
Observation	520				520			

Note: One asterisk, two asterisks, and three asterisks denote significance at 10%, 5%, and 1% levels, respectively

analysis revealed that the positive and negative parts of stock market development show an insignificant impact in the short run. However, in the long run, the positive role of stock market development leads to enhanced carbon emissions. Simultaneously, the negative part depicts the decrease in the stock market efficiency significantly which mitigates the carbon emissions in the long run. This finding is the same with Al-Mulali et al. (2019) and Zhang et al. (2011) and contradicts with Paramati et al. (2017) and Tamazian et al. (2009). The primary reason is that the development in the stock market which stimulates economic growth may discharge environmental pollution.

Although, the stock market development could substantially impact pollution through traditional sources of energy-consuming. Investment in effective technologies and renewable energy by financial development can improve the environmental quality (Hafeez et al. 2019). The outcomes infer that FDI deteriorates that environmental quality in the domestic economy (Yang et al. 2020b). A significant construction and

demolition waste nurtures governance problems concerning land resources, and triggering air pollution (He et al. 2020; Liu et al. 2019; He et al. 2018; He et al. 2018). For Chinese economy, environmental sector is responsible to control the life cycle of greenhouse gas (GHG) emissions (He et al. 2020; He et al. 2018; Chen et al. 2017; Chen et al. 2020). Another reason is that the stock market is achieving dirty-economic growth instead of green-economic growth. A stock market developed also increases income and wealth, which in turn increases environmental pollution in Asian economies. The aging population in China highlights the significance of elderly long-term care services (Chen and Liu 2021). In China, perceived environment quality can be enhanced through street greenery to paddle the sense of community (SoC) score (Li et al. 2021a).

Although, Paramati et al. (2017) considered the stock market development as the most influential source of financing clean energy projects, while it has not play important role in environmental quality in Asia. The Qinghai–Tibetan Plateau,

China, is one of the furthest sympathetic zones regarding climate change (Tian et al. 2020). This finding infers that positive shock in stock market increases the dirty economic activities that are environmentally unfriendly in Asia. Stock market is one of the additional sources of funding, and Asian economies invest more in the fossil fuel energy sector and pollute the environment. This also infers that Asian stock markets only focus on the increase of economic activities without paying consideration towards the environmental quality. Our finding is also supported by Dasgupta et al. (2006), who noted that the stock market helps firms to enhance capital structure and thus upsurges energy consumption as well pollution emissions. Similar results are found by Zhang et al. (2011) for China, who noted that China's stock market has not efficiently reduced carbon emissions. Integrated energy system total energy output of Chinese coastal areas is a good matching ability of energy supply and demand (Zhao et al. 2020; Zuo et al. 2020; Yang et al. 2020a, 2020b). Our study also supports the "supply-leading hypothesis" as Ngare et al. (2014) noted that stock market is a pre-condition to economic growth by helping savings in the form of financial assets and, hence, stimulating environmental pollution. Additionally, the turns out infer that the stock market did not offer environmental performance incentives in the Asian economies.

Thus, panel C demonstrates the various diagnostic tests. The ECM value has a significant and negative effect, indicating the speed of adjusting towards its equilibrium path in the long run. Further, the critical value of F-statistics is greater than the upper bound value; it also confirms the long-run association between the panel series.

Conclusion and policy

The influence of the stock market should not be ignored in the economy because, like the financial sector development, it plays an imperative role in the environment (Hafeez et al. 2018; Ullah and Ozturk 2020). It is usually noted that a well-established financial system constitutes a potentially important mechanism for green economic activities by reducing environmental pollution in advanced economies (Paramati et al. 2017). Therefore, this study analyses the asymmetric influence of stock market on CO₂ emissions in Asian economies over the data period from 1995 to 2019. To get the study objective, we use the nonlinear ARDL model in the panel framework.

The linear panel ARDL findings show that stock market is a positive effect on CO₂ emissions in the short and long run in Asia. Moreover, nonlinear panel ARDL indicates that positive changes in stock market significantly aggravate CO₂ emissions in the long run. This result also revealed that negative changes in stock market have negatively influenced CO₂ emissions in the long run in Asia. The short-run effect of stock

market on CO₂ emissions is asymmetric in magnitude and direction, because the positive change in stock market has negative influence on environmental pollution, while negative shock in stock market has positive impact on environment. Our asymmetric results in the robust analysis are also maintained and stable in panel NARDL estimates in the short and long run. Regarding control variables, GDP, financial development, and energy consumption have positive effects on CO₂ emissions in the long run, while GDP and financial development have also mitigated the environment in the short run in Asia.

Furthermore, policymakers should also study the asymmetric behavior of the stock market while formulating green finance, clean environment, and green growth policies. Authorities should also improve the environmental quality through the utilization of stock market. In sum, authorities should also pay high devotion to get a stable financial environment in order to encourage the relationship between stock market and environment. The listed firms may also familiarize public-private partnership in investments into clean energy projects. The findings of this study are also important for Asian economies, and findings can be generalized to other developing countries. Policymakers should redesign policies that focus on renewable or clean energy and technology innovation channels of stock market which can improve environmental sustainability. The study desires that Asian economies should also introduce "green bonds" in the stock market for green business activities.

One limitation that our study could not include the other types of environmental pollution. We suggest future scholars to consider other proxies of environmental pollution in analysis. Scholars can conduct similar research for other economies by using the nonlinear panel ARDL. Moreover, future research can also consider the nonlinear behavior of the stock market in the environment with quantile regression in terms of their size and efficiency. Moreover, future studies can also address the financial crises in the panel NARDL data.

Availability of data and material The datasets/materials used and/or analyzed for the present manuscript are available from the corresponding author on reasonable request.

Author contribution Carlos Samuel Ramos Meza and Cong Phan The have provided the idea. Maryam Kashif, Vipin Jain, Randhir Roopchund, Gniewko Niedbala, and John William Grimaldo Guerrero have done the data acquisitions and analysis and written the whole draft. Carlos Samuel Ramos Meza and Cong Phan The read and approved the final version.

Declarations

Ethics approval Not applicable

Consent to participate I am free to contract any of the people involved in the research to seek further clarification and information.

Consent for publication Not applicable

Conflict of interest The authors declare no competing interests.

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