The role of stock markets on environmental degradation: A comparative study of developed and emerging market economies across the globe

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Abstract

It is well established in the literature that stock markets increase both economic activities and energy consumption across countries. Therefore, it is commonly believed that stock markets are expected to have a significant effect on CO_2 emissions. However, it is not known whether these stock markets can contribute to more or less CO_2 emissions. Hence, the goal of this study is to examine the impact of stock market indicators on CO_2 emissions across a global panel of both developed and emerging market economies. The results establish that stock market indicators have a significant negative and positive impact on carbon emissions in developed and emerging market economies, respectively. Furthermore, the findings illustrate the presence of the Environmental Kuznets Curve (EKC) hypothesis, implying that stronger stock markets lead to a further decline in carbon emissions. Given these findings, the study argues that the role of stock markets in the abatement of CO_2 emissions significantly varies across both developed and emerging market economies. Significant implications have to do with the fact that developed markets might have initiated effective policies on listed firms to minimize carbon emissions, while emerging markets are yet to achieve this.

JEL classification: G28, O16, P28, Q42

Keywords: Stock market indicators, CO_2 emissions, Developed-emerging market economies, EKC hypothesis

1. Introduction

The rapid increase of both carbon dioxide (CO_2) emissions and the deterioration of the environment, are considered two of the most important issues in both developed and emerging countries. The rapid increase in CO_2 emissions is currently adversely affecting the levels of environmental quality, with some of the major catastrophes in the recent past, i.e. the frequent and ferocious cyclones in Bangladesh, in the Philippines and in the U.S., the prolonged drought in Chile, the outburst of flood in Malaysia and Pakistan, the bush fires in Australia and Russia, and the Tsunami effect in Japan, being the consequences of such environmental degradation (Shahbaz et al., 2011). Hence, identifying the determinants of CO_2 emissions has now become an important issue and also received substantial attention by global researchers, as it can assist policymakers to formulate effective policies in relevance to energy consumption and environmental degradation. For example, a wide strand of the relevant literature investigates the impact of certain drivers on CO_2 emissions, including economic growth (de Bryun et al., 1998; Zhang, 2000; Narayan et al. 2016), energy consumption (Soytas et al., 2007; Zhang and Chang, 2009), financial development (Tamazian et al., 2009; Zhang, 2011), trade openness (Frankel and Rose, 2005; Sbia et al. 2014), urbanization (Hossain, 2011) and industrialization (Nag and Parikh, 2000). However, the impact of stock market development on carbon emissions has been rarely investigated in the existing literature.

The development of stock markets has impacted CO_2 emissions in various ways. The most prominent way is expanding business. Stock market developments are particularly attractive to business activities because they allow access to an additional source of funding, and equity financing, in addition to debt financing. The significant growth of business may consume more energy and contribute to increasing CO_2 emissions (Sadorsky, 2011). Moreover, increased stock market activities generate a wealth effect, by diversifying risks for both consumers and business enterprises that in turn affect both energy consumption and environmental pollution (Mankiw and Scarth, 2008). The stock market is often considered as a prominent economic indicator, with increased stock market activities being viewed as a symbol of economic growth and development, which in turn enhances both business and consumers' confidence. Moreover, increased economic confidence intensifies the production of manufacturing goods and services, leading to increased carbon emissions (Sadorsky, 2011). Stock markets help to reduce environmental degradation by enforcing strong regulations and actions onto listed companies/enterprises, so as they use greener technologies which may lead to higher energy efficiency and reduced industrial pollution (Lanoie et al., 1997). Efficient stock markets also rank and compare their listed firms with respect to their environmental performance, which in turn encourages both large and smaller polluters to reduce their pollution levels (Lanoie et al., 1997). Moreover, stock market developments increase funding sources for investments in clean energy projects which may also lead to reduced CO_2 emissions (Paramati et al., 2016).

The countries considered in this study cover a major part of global developed and emerging market economies. The developed market economies considered in this study are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Hong Kong (HK), Ireland, Israel, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Singapore, Spain, Sweden, Switzerland, the United Kingdom (UK), and the United States (US), while the emerging market economies include: Brazil, Chile, China, Colombia, Czech Republic, Egypt, Greece, Hungary, India, Indonesia, Korea, Malaysia, Mexico, Peru, the Philippines, Poland, Russia, South Africa, Thailand and Turkey. The above countries account 66% of the global population, 85% of global GDP, 80% of the world's energy and 76% of global carbon emissions (WDI, 2015). Moreover, the sample covers the top five CO_2 emitters of the world: China, the U.S., India, Russia and Japan, as well as the most emerging economies: China, Russia, India, Brazil and South Africa. Hence, in the light of above points, the analysis will investigate the relationship between stock market indicators and CO_2 emissions. In fact, this kind of work is crucial for both developed and emerging market economies in relevance to policies that lead to carbon emissions intensity reductions and to reasonably evaluate the difficulties to combat environmental degradation. In addition, if there is a significantly positive relationship between stock market developments and carbon emissions, then any further development of stock markets in both types of countries may increase emissions in a way that has not been accounted for.

The contribution of this study is five-fold. First, to the best of our knowledge, this is the first study that empirically explores the validity of the Environmental Kuznets Curve (EKC) hypothesis in the context of stock market developments. The EKC hypothesis postulates that there is an inverted U-shape relationship between GDP per capita and environmental degradation, implying that at the early stage of economic development, a developing country prioritizes economic development than the associated environmental damage. However, over time, as the economy grows, the country can afford investing stronger in green technologies, increasing energy efficiency and adopting cleaner energy sources (Narayan and Narayan, 2010). Hence, these factors are expected to assist to produce higher levels of environmental friendly goods and services. In the context of the stock markets and CO_2 emissions relationship, we also expect that as stock markets are developing, it leads to the improvement of the environmental quality by promoting the use of stronger green technologies. Second, this is also probably the first study that offers a comparative analysis between developed and emerging market economies on the nexus of stock market developments and environmental issues. The comparative analysis is considered to be interesting by the fact that the status of stock market developments, the nature of CO_2 emissions, the pace of economic growth, the quality of institutions, and the usage of technology is significantly different in developed from the emerging market economies. Third, although Tamazian et al. (2008) is the only panel study that uses stock market values added as a proxy for financial developments and investigates their impact on the environmental quality, stock market values represent only the scale of the market but not its market efficiency. Considering this limitation, this study incorporates variables that cover both stock market scales and efficiency issues. Fourth, the studies by Tamazian et al. (2008), Zhang (2011) and Abbasi and Riaz (2016) are the only studies that investigate the role of stock market developments in CO_2 emissions in the cases of China and Pakistan. However, none of these studies follow any theoretical framework that validates their empirical model. To avoid this limitation, this study aims at employing the environmental impact (also popularly known as IPAT) model which is a widely used theoretical model to investigate the factors that drive the environmental degradation. Finally, this paper makes use of several robust panel econometric techniques which account for cross-sectional dependence and heterogeneity in the analyses. Therefore, the findings derived from these analyses will provide more reliable and robust results.

The organization of this paper is as follows. The next section provides a description of the relevant literature, while Section 3 describes the empirical methodology and the data. Section 4 presents the empirical results and the associated discussion. Finally, Section 5 concludes the paper, while it offers certain policy implications and venues for future research.

2. Literature Review

Over the recent years, an extensive amount of studies have explored the link among financial development, economic growth, energy consumption and environmental degradation across a number of countries and regions. The results, however, have not been uniform across countries, periods or estimation methodologies. For example, a group of studies find that financial development can induce economic growth, which in turn increases both energy consumption and carbon emissions [Sadorsky (2010, 2011) for Central and Eastern Europe countries and emerging countries, Zhang (2011) for China, Al-Mulali and Che Sab (2012a, b) for Sub-Saharan African countries and 19 other selected countries, Shahbaz and Lean (2012) for Tunisia, Islam et al. (2013), Tang and Tan (2014) for Malaysia, Çoban and Topcu (2013) for the European Union (EU) countries, Komal and Abbas (2015) for Pakistan, Al-Mulali et al. (2015) for a panel of 129 countries, and Abbasi and Riaz (2016) for Pakistan]. By contrast, a number of other studies find that financial development can reduce both carbon emissions and energy consumption [Tamazian and Rao (2010) for transition countries, Jalil and Feridun (2011) for China, and Shahbaz et al. (2013) for Indonesia]. However, Ozturk and Acaravci (2013) for Turkey, Omri et al. (2015) for MENA countries, and Le (2016) for Sub-Saharan African countries conclude that financial development has no effect on carbon emissions.

In terms of the proxies that have been used for measuring financial development, the majority of the above studies have used banking sector indicators, such as that of domestic private credit (Shahbaz and Lean, 2012; Çoban and Topcu, 2013) and domestic credit by the banking sector as a share of GDP (Al-mulali et al. 2015; Tang and Tan, 2014). However, only a few studies (Sadorsky 2010, 2011; Coban and Topcu, 2013; Abbasi and Riaz, 2016) employ stock market indicators as proxies for financial development, although stock markets have a significant impact on economic activities, energy consumption and CO_2 emissions.

A wide range of the literature, both theoretically and empirically, argue that stock market developments can substantially induce economic growth. The theoretical literature claims that there are two ways through which stock market developments may influence economic growth. First, stock markets provide an alternative channel for savings mobilisation and better resource allocations, which help businesses to finance large projects via equity issues. These large projects undoubtedly spur economic growth (Levine and Zervos, 1998;

Adjasiand Biekpe, 2006). The second channel is based on the ground that a well-functioning stock market mitigates principal agent problems that lubricate savings and promote capital accumulation, technology advances and economic growth in the long run (Levine, 1997; Han, 2001).

Empirically, Spears (1991), Pardy and Mundial (1992) and Atje and Jovanovic (1993) are the pioneer studies that provide supportive evidence that stock market developments are positively and significantly correlated with GDP per capita. However, most of the earlier studies suffer from various statistical limitations, including endogeneity issues with unmeasured cross country heterogeneity. Subsequently, substantial research has been implemented with larger panel data sets and longer time series to address the criticisms of the earlier studies. In particular, Arestis et al. (2001) investigate the role of stock markets in economic growth in the context of five developed countries. Their study concludes that stock markets support significantly economic growth. Beck and Levine (2004) examine the effect of stock markets and banking institutions on economic growth using a panel data. Using generalized-method-of moments (GMM) approaches, their study finds that both stock markets and banks positively influence economic growth. Cooray (2010) investigates the influence of stock markets on economic growth for a cross section of 35 developing countries. Their study finds that stock market activities enhance economic growth. A number of more recent studies, such as Carp (2012) for emerging markets in the Central and Eastern Europe and Ngare et al. (2014) for Africa also provide similar findings. In contrast, another group of papers provide supportive empirical evidence that stock markets have a significant negative impact on economic growth. Singh (1997) suggests that stock market volatility could exacerbate macroeconomic instability, which may frustrate the patterns of economic growth in developing countries. Devereux and Smith (1994) claim that increased stock market activities can lead to greater risk sharing and, therefore, lower economic growth.

Paramati and Gupta (2011) document that economic growth promotes stock market developments in India, while Boubakari and Jin (2010) report that stock market developments have no significant influence on economic growth.

In terms of the stock market-growth nexus, there have been poor research efforts that examine the relationship between stock markets and energy consumption. Considering 22 emerging countries, Sadorsky (2010) investigates the impact of stock markets on energy consumption. By measuring stock market variables as stock market capitalization to GDP, stock market value traded to GDP, and stock market turnover, the author provides supportive evidence that stock markets have a positive and statistically significant effect on energy consumption. Sadorsky (2011) also examines the influence of stock market turnover on energy consumption in the case of Central and Eastern European countries. The empirical analysis illustrates that stock market turnover has a positive and significant effect on energy consumption. In a country specific study, Zhang et al. (2011) investigate the impact of stock markets on the Chinese energy consumption. The results of Granger causality suggest that China's stock market scale enlargement is a significant driver for energy consumption, while the effect of stock market efficiency is found to be nil. Coban and Topcu (2013) investigate whether financial development in the banking or the capital markets is associated with energy consumption in the context of the EU. Their study reveals that strong stock market developments help to increase energy consumption in the case of the EU-15. However, this is not the case for the EU-27. Chang (2015) explores the role of financial development in energy consumption for a sample of 53 countries. Our study uses the value of traded stocks and stock market turnover as proxies for financial development and highlights that both indicators reduce energy consumption in the advance economies, but they increase it in the case of emerging and developing countries.

A limited literature is also available that examine the influence of stock markets on environmental degradation. Lanoie et al. (1998) examine the role of capital markets for pollution control. Evidence drawn from the US and Canadian markets documents that efficient capital markets improve the environmental performance by implementing strong enforcement actions to their listed firms. Moreover, stock markets offer incentives to improve such environmental performance. Moreover, Lanoie et al. (1998) investigate the role of stock markets in controlling pollution in the context of developed countries, while Dasgupta et al. (2001) share the same goal in the context of developing countries. The latter study focuses on the economies of Argentina, Chile, Mexico and the Philippines. Their evidence illustrates that stock markets boost up firms' environmental performance through a number of public disclosure mechanisms, even though their stock markets have limited enforcement resources. Gupta and Goldar (2005) examine whether stock markets penalize any environment-unfriendly behaviour in the case of India. The findings illustrate that markets generally penalize the firms with an unfriendly behaviour towards the environment, and hence, they play an important role for environmental management. Tamazian et al. (2009) examine the impact of stock markets on environmental degradation in the cases of Brazil, Russia, India and China (BRIC). Their study uses 'stock market value added' as a proxy for stock market developments. The results highlight that stock markets decrease significantly carbon emissions in selected countries. Zhang (2011) explores the influence of stock markets on carbon emissions along with other financial development indicators. His findings indicate that China's stock market scale has a comparatively larger impact on carbon emissions whereas the influence of stock market efficiency on these emissions seems relatively weaker. The author supported this finding by arguing that the history of China's stock markets is extensively shorter compared with that in developed countries. Therefore, the related market mechanism design is not complete and standardized, and the efficiency of the market has not reached the level where it can significantly reduce carbon emissions. Very recently, Abbasi and Riaz (2016) examine the role of stock markets on carbon emissions in the case of Pakistan. The study finds that stock market developments substantially increase carbon emissions. Finally, Iatridis (2013) documents that the environmental disclosure of the companies is positively associated with the environmental performance in Malaysia.

Overall, the relevant literature suggests that there are adequate studies on the linkage between stock markets, economic growth and energy consumption. Although a few empirical studies are available on the relationship between stock markets and environmental performance, none of them investigates the validity of the EKC hypothesis in relevance to the presence of stock markets, while existing studies have not followed any theoretical framework to construct their empirical model. Hence, our study is designed to narrow these research gaps and, by contributing to the literature, to provide fresh insights for policy makers.

3. Methodology and data

3.1 Model specification

Given that the objective is to empirically examine the long-run equilibrium relationship, long-run elasticities and short-run causalities among the CO_2 emissions, population density, GDP per capita, energy efficiency and stock market indicators across a number of developed and emerging market economies, the analysis develops the following models, using the theoretical approach of the IPAT environmental model (Ehrlich and Holdren, 1971) to determine the drivers of CO_2 emissions. This theoretical model is built based on the association among the population, income, technology and the environmental impact, as described in the following equation:

$$I = P \times A \times T \quad (1)$$

where, I is the pollution or the environmental impact, which is sourced from the population (P), the level of economic activities or per capita consumption (A) and the technological level or efficiency, defined as the amount of pollution per unit of economic activity or consumption (T). In the later period, this basic model has been further extended by Dietz and Rosa (1994, 1997), to a stochastic version which is popularly known as the *STIRPAT* (STochastic Impacts by Regression on Population, Affluence and Technology) model. This model is not just an accounting equation, but it can be used to test the hypotheses under study. Thus, based on the common specification of the *STIRPAT* model, the following equations are provided:

$$CO_{2it} = f\,(PD_{it}, GDPPC_{it}, EE_{it}, SMPC_{it}, v_i) \quad (2)$$

$$CO_{2it} = f\,(PD_{it}, GDPPC_{it}, EE_{it}, STPC_{it}, v_i) \quad (3)$$

where, CO_2, PD, GDPPC, EE, SMPC and STPC represent carbon dioxide emissions per capita, population density, GDP per capita, energy efficiency, stock market per capita and stocks traded per capita, respectively, while v_i represents individual fixed country effects. Similarly, subscript i $(i = 1,\ldots, N)$ and t represent country and time period $(t = 1,\ldots, T)$, respectively.

3.2 Panel cointegration

The analysis employs panel cointegration methodology to investigate the long-run equilibrium relationship across the variables under study. The study makes use of the Durbin-Hausman test, recommended by Westerlund (2008), to explore the presence of cointegration. In particular, this test is applied under very general conditions because it does not rely heavily on a priori knowledge of the integration order of the variables included in the modelling approach. Additionally, it allows for cross-sectional dependence modelled by a factor model in which the errors in equations (2) and (3) are obtained by idiosyncratic innovations and unobservable factors that are common across units of the panel.

3.3 Long-run CO_2 emission elasticities

Finally, the analysis applies a panel methodology, which takes into account both cross-section and time dimensions of the data to estimate the long run relationships described in Equations (2) and (3). However, when the errors of a panel regression are cross-sectionally correlated then standard estimation methods can lead to inconsistent estimates and incorrect inference (Phillips and Sul, 2003). In order to take into account the cross-sectional dependence we implement a novel econometric methodology, namely, the Common Correlated Effects (CCE) by Pesaran (2006). He suggests a new approach to estimation that takes into account cross sectional dependence. The proposed methodology allows individual specific errors to be serially correlated and heteroskedastic. It allows for cross-sectional dependence in the regression errors. The presence of this dependence, i.e. the positive cross-sectional correlation with the regression error, gets stronger, and thus, the true critical value of the ordinary t -statistics becomes larger in absolute value, so that we do not know the proper critical values. If, moreover, cross-sectional dependence in the error term is correlated with the regressors, which may be the case for many practical applications in economics and finance, then the estimated coefficients are biased and inconsistent (Beck and Katz, 2011). Pesaran (2006) provided solution to this problem by adding common factors to the panel regressions. There are advantages associated with the factor augmented regression. First, there is no need to perform a pre-test for endogeneity, since the factor augmented regression becomes valid regardless of the correlation of the error term with the regressors, and, second, the factor augmented regression is more efficient than the original (long-run) method, because by including common factors as additional regressors, the factor augmented regression reduces the variance of the estimators and sharpens statistical inference (Bai, 2009).

3.4 Data

The sample countries from both developed and emerging markets are selected based on the Morgan Stanley Capital International (MSCI), while data availability dictated the time span, i.e. 1992 to 2011.[1] Hence, this study makes use of a balanced panel data set on developed and emerging market economies. Data on CO_2 emissions, population density, GDP per capita, energy intensity, stock market capitalization and stocks traded are obtained from the World Development Indicators (WDI) online database published by the World Bank. The description of these variables is as follows: carbon dioxide emissions (CO_2) are measured in per capita metric tons; population density (PD) is the total population divided by the land area in square kilometres; gross domestic product per capita (GDPPC) is measured in constant 2005 US dollars; energy efficiency (EE) is an indication of how much energy is used to produce one unit of economic output; stock market capitalization per capita (SMPC) is the total market capitalization divided by the total population of the country, in constant US dollars; and finally, the total value of shares traded per capita (STPC) is measured as total stocks traded divided by the total population of the country, in constant US dollars.[2] By following a number of previous studies (Alam et al., 2016; Bhattacharya et al., 2016; and

1 The per capita CO_2 emissions data is only available until 2011 from World Bank and EIA. Therefore, it is restricted our sample period to 2011.

2 The WDI provides data in current prices for market capitalization and stocks traded. Hence, we have converted these current price data into constant prices by dividing with the consumer price index. The similar approach is followed by Sadorsky (2011, 2012).

Paramati et al., 2016), we convert all of these variables into natural logarithms before the estimation begin as the estimated coefficients can be treated as the elasticities.

4. Empirical findings and discussion

4.1 Summary statistics on individual countries and panels

Table 1 presents summary statistics for the selected variables in both developed and emerging market economies during the period 1992 to 2011. Among the developed market economies, the United States (19.135 metric tons), Australia (16.756 metric tons) and Canada (16.301 metric tons) are the highest, while Portugal (5.486 metric tons), Switzerland (5.548 metric tons) and Hong Kong (5.586 metric tons) are the lowest emitters of per capita CO_2. In the case of emerging market economies, there is a significant difference of per capita CO_2 emissions among the selected countries, with the highest in Czech Republic (11.765 metric tons), Russia (11.405 metric tons) and Korea (9.332 metric tons), whereas the lowest in the Philippines (0.856 metric tons), India (1.192 metric tons) and Peru (1.235 metric tons). The highest per capita market capitalization is found to have in Switzerland ($1042.089), Hong Kong ($1007.561) and the U.S. ($529.983), while Portugal ($62.834), Austria ($88.352) and Italy ($103.150) are the lowest in the developed market economies.

[Insert Table 1 here]

Likewise, among the emerging market economies, Brazil ($356.240) and Turkey ($249.314) have the highest per capita market capitalization while India ($5.865) and Indonesia ($8.411) have occupied the bottom positions. The per capita stocks traded shows that Switzerland ($973.175), the U.S. ($873.026) and Hong Kong ($815.055) have the highest while New Zealand ($38.769), Portugal ($40.392) and Austria ($42.493) have the lowest per capita stocks traded in the selected developed market economies. In the case of emerging market economies, it ranges from $238.150 in Turkey, $210.396 in Korea and $168.779 in Brazil to

$1.459 in Peru, $1.716 in Colombia and $2.641 in Philippines. Finally, all the sample countries enjoyed positive GDP growth during the sample period. More specifically, Singapore achieved the highest GDP growth (6.525), followed by Israel (5.222) and Ireland (4.890) while Japan (0.778), Italy (0.949) and Germany (1.381) have the lowest in the developed market economies. Similarly, as expected, China has witnessed a significant growth (10.502) along with India (6.848) and Malaysia (5.721), whereas Russia (1.128), Egypt (1.565) and Hungary (1.917) have the lowest among emerging market economies.

Table 2 presents summary statistics for the full sample, as well as for both developed and emerging market economies. As we can see, the mean for per capita CO_2 emissions is 7.381 metric tons in full sample, 9.559 metric tons in developed and 4.876 metric tons in emerging market economies. This indicates that the per capita CO_2 emissions in developed market economies are almost double than those of emerging market economies. Similarly, the average per capita GDP is $21214.700, $34470.160 and $5970.923 in the full sample, developed and emerging market economies, respectively. The per capita market capitalization varies highly between the developed and emerging market economies. The per capita market capitalization in developed market economies is $333.479, whereas in emerging market economies, it is only $68.998. Finally, per capita stocks traded also differ considerably across the markets. For example, per capita stocks traded are found to be $183.571, $303.780 and $45.330 in the full sample, developed and developing market economies, respectively. This also indicates that the developed market economies have higher per capita stocks traded than the emerging market economies.

Overall, the summary statistics suggest that the developed market economies have higher per capita CO_2 emissions, GDP, market capitalization and stocks traded compared to the emerging market economies.

[Insert Table 2 here]

4.2 Analysis of cross-sectional dependence

In the first step of the empirical analysis, we examine the degree of residual cross-section dependence through the cross-sectional dependence (CD) statistic by Pesaran (2004). Under the null hypothesis of cross-sectional independence, the CD test statistic follows asymptotically a two-tailed standard normal distribution. The results, reported in Table 3, uniformly reject the null hypothesis of cross-section independence regardless of the number of lags in the ADF regressions.

[Insert Table 3 here]

Next, a second-generation panel unit root test is employed to determine the degree of integration in the respective variables. The Pesaran (2007) panel unit root test does not require the estimation of factor loading to eliminate cross-sectional dependence. The null hypothesis is a unit root for the Pesaran (2007) test and the results are reported in Table 4. They support the presence of a unit root across all variables under consideration, both in the full sample and in the developed and emerging market economies samples.

[Insert Table 4 here]

4.3 Analysis of the long-run equilibrium relationship

The above analysis indicates the potential presence of a long-run equilibrium relationship among the variables of equations (2) and (3). To examine the long-run relationship we employ the Durbin-Hausman test (Westerlund, 2008). The empirical results of the DH_g and DH_p tests are reported in Table 5. They illustrate that the null hypothesis of no-cointegration is rejected at the 1% significance level across both equations. The findings retain their robustness not only for the full sample, but also for both developed and emerging economies samples.

[Insert Table 5 here]

4.4 Analysis of long-run CO_2 emission elasticities

Since, we established the long-run equilibrium relationship among the variables, the next step applies a panel methodology which takes into account both cross-section and time dimensions of the data to estimate the long run relationships described in Equations (2) and (3). This methodology is the Common Correlated Effects (CCE) approach recommended by Pesaran (2006), which takes into account the presence of cross-sectional dependence.

Therefore, our goal in this section is to investigate the long-run impact of stock market indicators on CO_2 emissions across the panels of full sample, developed and emerging market economies. The analysis converts all of the variables into natural logarithms; hence, the estimated coefficients from the CCE models can be interpreted as long-run elasticities. Moreover, given that it is practically difficult, but potentially unobservable, for energy consumption and carbon dioxide emissions in the same country and year to be similar, the reported p-values are based on standard errors that have been clustered through the methodological approach recommended by Petersen (2009). The panel cointegration results are reported in Table 6. The findings show that SMPC has a statistically significant positive effect on CO_2 emissions of full sample and emerging market economies while it has a negative impact on the developed market economies. For instance, a 1% increase in SMPC for full sample and emerging market economies raises CO_2 emissions by 0.044% and 0.068%, respectively, while it declines in developed market economies by 0.025%. This indicates that the growth of stock market per capita in full sample and emerging market economies has a substantial positive effect on the CO_2 emissions. This further suggests that the impact is more on the full sample countries than those of the emerging market economies. On the other hand, the growth of stock market per capita has a considerable negative effect on the CO_2 emissions of the developed market economies. Similarly, the results imply that STPC also has a positive impact on the CO_2 emissions in both the full sample and in emerging market economies, whereas it has a negative influence on the developed market economies. More specifically, a 1% raise in STPC decreases CO_2 emissions by 0.012% and 0.016% for the full sample and developed economies, respectively, while it increases them in emerging economies by 0.018%.

[Insert Table 6 here]

Moreover, we aim to examine whether the Environmental Kuznets Curve (EKC) hypothesis is valid between the stock market indicators and CO_2 emissions across all panels considered. Therefore, we squared the per capita stock market indicators and estimated the models using the CCE approach. The results are displayed in Table 7. The findings confirm the presence of the EKC hypothesis across all panel data sets. More specifically, a 1% increase in $SMPC^2$ decreases CO_2 emissions by 0.007% and 0.009% in both the full sample and developed economies, while it is still positive for the case of emerging market economies, but the impact on CO_2 emissions has been reduced to 0.006%. Similarly, a 1% raise in $STPC^2$ declines CO_2 emissions across all panel economies by 0.006%, 0.005% and 0.006%, respectively. These results imply that further growth of stock market indicators in both developed and emerging market economies is expected to significantly decline CO_2 emissions.

[Insert Table 7 here]

The findings of long-run elasticities have significant policy implications. For instance, the results in Table 6 highlight that the growth of stock market indicators in developed economies has a substantial negative effect on CO_2 emissions, implying that stock markets might have initiated environmental friendly policies and ensure the adoption of such policies by all firms listed on stock exchanges. As a result, listed firms in the developed economies might have adopted greener technologies to maximize their energy efficiency levels and reduce CO_2 emissions. However, this is not the case in the emerging market economies where stock markets growth has a positive impact on CO_2 emissions. Based on these findings, we argue that the emerging market economies are yet to implement effective environmental friendly policies to reduce CO_2 emissions, while policy makers should initiate suitable policies to minimize CO_2 emissions associated with the listed firms.

The results on the squared stock market indicators suggest that the presence of stock markets significantly declines CO_2 emissions in both the developed and emerging economies, implying that the significant growth of stock markets in terms of their scale and efficiency is expected to have a considerable negative effect on carbon emissions across both developed and emerging market economies. In other words, there is a potential scope that the presence of stock markers plays an important role in reducing carbon emissions across countries. Therefore, such findings suggest that the policy makers should initiate effective policies in relevance to stock exchanges so as all listed firms adopt greener technologies leading to the reduction of CO_2 emissions. The above findings are consistent with those provided by Paramati et al. (2016) who document that stock markets promote clean energy consumption and, hence, reduce CO_2 emissions.

5. Conclusion and policy implications

It is well documented in the literature that the growth of stock markets has a significant positive impact on both the economic activity and energy consumption across developed and emerging economies. However, it is not very clear from the prevailing literature whether stock markets increase or decrease CO_2 emissions in both developed and emerging market economies. Given this knowledge gap in the literature, this study aimed to fill this void by investigating the effect of stock market indicators on CO_2 emissions across the panels of developed and emerging market economies. The analysis also examined whether the EKC hypothesis was valid between stock market indicators and CO_2 emissions. To achieve these objectives, the analysis employed robust panel econometric modelling approaches and annual data, spanning the period 1992 to 2011, on 23 developed and 20 emerging market economies around the world.

The empirical findings showed that there was a significant long-run equilibrium relationship between stock market indicators and CO_2 emissions across both the developed and emerging market economies. Similarly, the long-run CO_2 emission elasticities suggested that stock market indicators had a significant negative/positive effect on CO_2 emissions in the cases of developed and emerging economies, respectively. However, the squared stock market indicators implied that the significant growth of stock markets, in terms of their size and efficiency, could substantially reduce CO_2 emissions both in developed and emerging economies. These findings confirmed the presence of the EKC hypothesis between stock market indicators and CO_2 emissions.

Overall, the above results suggest that stock market indicators have a diverse relationship with CO_2 emissions in the cases of developed and emerging market economies. This is implying that the growth of stock markets in developed countries is substantially reducing CO_2 emissions, while it is increasing them in the case of emerging economies. Therefore, policy makers in developed economies might have implemented and instructed all listed firms to adopt greener technologies to reduce CO_2 emissions and also increasing the share of renewable and clean energy consumption. These all factors might have significantly assisted those firms to reduce their CO_2 emissions. In contrast, it is clearly evident that this is not the case in emerging economies. This might be due to the institutional inefficiency, the presence of conventional production activities and the paucity of renewable and clean energy availability. Therefore, the policy makers in emerging market economies should initiate effective policies to promote strong institutional set ups, to encourage renewable energy production and provide incentives to the firms to adopt greener technologies, which will all lead to the reduction of CO_2 emissions.

Finally, the findings indicated the presence of the EKC hypothesis between stock market indicators and CO_2 emissions across both developed and emerging economies. Based on this evidence, we argue that further growth of stock markets, in terms of their size and efficiency, is expected to play an important role for the reduction of carbon emissions across markets, implying that stock markets should initiate effective policies that will motivate listed firms to adopt environmental friendly policies leading to reduce CO_2 emissions. Towards this end, this study suggests future research attempts need to investigate, on a country level, whether high frequency data can be used so as to provide country specific evidence which will assist both policy makers and government officials to frame more specific policies that ensure the mitigation of CO_2 emissions.

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Table 1: Summary statistics on individual countries, 1992-2011

S. No		CO_2	PD	GDPPC	EE	SMPC	STPC	GDPG
				Developed market economies				
1	Australia	16.756	2.558	31239.351	6.498	357.788	263.152	3.313
2	Austria	8.031	98.192	35970.436	4.173	88.352	42.493	2.055
3	Belgium	10.627	344.790	34386.783	6.344	215.774	81.165	1.877
4	Canada	16.301	3.443	32976.311	9.098	344.527	237.470	2.655
5	Denmark	10.014	126.439	45328.632	3.843	264.561	196.739	1.695
6	Finland	11.140	17.099	34639.526	8.237	329.617	325.445	2.486
7	France	5.962	112.912	32864.506	5.122	228.693	203.560	1.715
8	Germany	10.033	235.015	33846.795	4.787	143.035	173.343	1.381
9	Hong Kong	5.586	6347.317	24464.874	2.229	1007.561	815.055	4.030
10	Ireland	9.852	57.902	41400.471	3.862	204.883	93.515	4.890
11	Israel	9.080	298.282	19497.678	4.817	167.851	87.644	5.222
12	Italy	7.609	195.835	30292.967	3.600	103.150	118.830	0.949
13	Japan	9.410	347.926	34474.970	5.040	263.046	222.526	0.778
14	Netherlands	10.620	473.913	39014.885	5.148	363.088	418.986	2.246
15	New Zealand	7.927	15.040	25168.569	6.257	107.577	38.769	2.970
16	Norway	8.800	12.472	61098.797	4.197	293.592	310.323	2.523
17	Portugal	5.486	112.737	17707.000	3.879	62.834	40.392	1.519
18	Singapore	10.484	6061.300	26361.547	4.218	530.507	328.633	6.525
19	Spain	6.811	84.339	24052.859	4.054	178.638	267.741	2.366
20	Sweden	5.790	21.889	38839.056	6.729	385.426	394.914	2.348
21	Switzerland	5.548	185.075	52896.823	3.138	1042.089	973.175	1.680
22	United Kingdom	8.863	246.876	35896.341	4.908	457.440	480.032	2.224
23	United States	19.135	31.162	40394.425	7.187	529.983	873.026	2.639
				Emerging market economies				
1	Brazil	1.802	21.420	4629.807	4.049	356.240	168.779	3.271
2	Chile	3.668	20.748	7011.910	4.313	87.811	12.509	5.054
3	China	3.772	135.021	1507.464	11.465	11.878	17.560	10.502
4	Colombia	1.528	37.122	3317.078	3.143	15.658	1.716	3.610
5	Czech Republic	11.765	133.387	11933.594	8.416	29.602	15.842	2.597
6	Egypt	1.988	70.967	1144.703	3.782	9.549	3.398	4.617
7	Greece	8.129	84.634	19692.926	4.036	100.453	57.607	1.565
8	Hungary	5.608	113.283	9499.822	5.773	24.651	19.020	1.917
9	India	1.192	363.062	656.868	6.788	5.865	5.203	6.848
10	Indonesia	1.435	119.281	1216.527	4.992	8.411	3.574	4.693
11	Korea	9.332	487.091	16318.863	7.564	107.777	210.396	5.233
12	Malaysia	6.078	73.116	5095.704	5.607	103.127	44.703	5.721
13	Mexico	3.789	53.883	7567.371	4.243	37.605	12.579	2.722
14	Peru	1.235	20.595	2608.337	2.874	13.680	1.459	5.006
15	Philippines	0.856	268.942	1135.888	4.384	10.660	2.641	4.045
16	Poland	8.373	125.125	7237.979	7.429	18.992	8.425	4.440
17	Russia	11.405	8.889	4731.548	12.329	41.269	23.529	1.128
18	South Africa	8.761	36.698	5196.125	10.879	124.900	42.873	2.871
19	Thailand	3.383	123.617	2467.714	5.422	22.315	16.644	4.076

20	Turkey	3.412	83.866	6448.226	3.684	249.314	238.150	4.270

Notes: 1) CO_2 emissions per capita in metric tons; 2) PD is the population density per square kilometres of land area; 3) GDP per capita in constant 2005 US$; 4) EE is the ratio between energy supply and GDP at PPP in constant 2011 $; 5) SMPC is per capita market capitalization in US$; 6) STPC is per capita stocks traded; and 7) GDPG is the annual GDP growth in percentage.

Table 2: Summary statistics on panel data sets, 1992-2011

	Full sample countries				Developed market economies				Emerging market economies			
	Mean	Max.	Min.	Std. Dev.	Mean	Max.	Min.	Std. Dev.	Mean	Max.	Min.	Std. Dev.
CO_2	7.381	20.208	0.742	4.345	9.559	20.208	2.655	3.766	4.876	14.001	0.742	3.545
PD	414.262	7363.210	2.277	1291.196	670.979	7363.210	2.277	1722.089	119.037	511.976	8.716	119.829
GDPPC	21214.700	69094.750	411.874	16599.050	34470.160	69094.750	13969.740	10649.800	5970.923	24307.570	411.874	5213.619
EE	5.547	18.355	1.749	2.426	5.103	10.531	1.749	1.734	6.059	18.355	2.378	2.954
SMPC	210.460	5827.546	0.232	335.368	333.479	1966.484	15.658	301.327	68.988	5827.546	0.232	316.504
STPC	183.571	2640.406	0.097	328.538	303.780	2416.661	5.874	382.760	45.330	2640.406	0.097	167.400
GDPG	3.355	21.829	-14.531	3.540	2.612	21.829	-8.269	2.848	4.209	14.276	-14.531	4.035

Table 3: Cross-section dependence (CD) test

Variables	Lags			
	1	2	3	4
CO_2	[0.00]***	[0.00]***	[0.00]***	[0.02]**
PD	[0.00]***	[0.00]***	[0.00]***	[0.01]***
GDPPC	[0.00]***	[0.00]***	[0.00]***	[0.00]***
EE	[0.00]***	[0.00]***	[0.01]***	[0.00]***
SMPC	[0.00]***	[0.00]***	[0.01]***	[0.02]**
STPC	[0.00]***	[0.00]***	[0.00]***	[0.01]***
SMGDP	[0.00]***	[0.00]***	[0.00]***	[0.01]***
STGDP	[0.00]***	[0.00]***	[0.00]***	[0.00]***
STTOR	[0.00]***	[0.00]***	[0.00]***	[0.01]***

Notes: Under the null hypothesis of cross-sectional independence the CD statistic is distributed as a two-tailed standard normal. Results are based on the test of Pesaran (2004). Figures in parentheses denote p-values. Significance levels: ***(1%) and **(5%).

Table 4: Panel unit root tests

Variable	Pesaran	Pesaran	Pesaran	Pesaran	Pesaran	Pesaran
	CIPS	CIPS*	CIPS	CIPS*	CIPS	CIPS*
	Full sample		Developed economies		Emerging economies	
CO_2	-1.16	-1.35	-1.50	-1.81	-1.27	-1.63
ΔCO_2	-3.69***	-4.71***	-11.17***	-14.83***	-8.39***	-9.32***
PD	-0.69	-0.93	-1.29	-1.68	-1.39	-1.55
ΔPD	-3.22***	-4.92***	-6.85***	-7.37***	-5.43***	-6.14***
GDPPC	-1.71	-1.96	-1.76	-1.93	-1.05	-1.32
ΔGDPPC	-5.12***	-5.39***	-5.62***	-5.94***	-3.38***	-4.41***
EE	-1.79	-1.90	-1.07	-1.58	-1.54	-1.82
ΔEE	-5.55***	-5.84***	-7.16***	-7.80***	-7.68***	-7.95***
SMPC	-1.97	-1.40	-0.24	-0.62	-0.2	-0.52
ΔSMPC	-6.01***	-6.95***	-3.95***	-4.56***	-5.81***	-6.39***
STPC	-1.06	-1.68	-0.69	-0.85	-0.82	-1.04
ΔSTPC	-6.68***	-6.85***	-4.20***	-5.03***	-4.64***	-4.98***
SMGDP	-1.19	-1.25	-0.93	-1.14	-0.94	-1.20
ΔSMGDP	-5.42***	-5.68***	-5.44***	-5.73***	-5.61***	-5.85***
STGDP	-1.34	-1.39	-1.24	-1.35	-1.28	-1.39
ΔSTGDP	-5.82***	-6.07***	-5.89***	-6.10***	-5.94***	-6.42***
STTOR	-1.31	-1.43	-1.29	-1.42	-1.36	-1.48
ΔTTOR	-6.11*	-6.38***	-6.01***	-6.36***	-6.19***	-6.38***

Notes: Δ denotes first differences. A constant is included in the Pesaran (2007) tests. Rejection of the null hypothesis indicates stationarity in at least one country. CIPS* = truncated CIPS test. Critical values for the Pesaran

(2007) test are -2.40 at 1%, -2.22 at 5%, and -2.14 at 10%, respectively. *** denotes rejection of the null hypothesis. The results are reported at lag = 4. The null hypothesis is that of a unit root.

Table 5: Westerlund's (2008) cointegration tests

Full sample		Developed economies	Emerging economies
CO_2 = f (PD, GDPPC, EE, SMPC)			
DHg	6.244[0.00]***	6.582[0.00]***	5.653[0.00]***
DHp	6.852[0.00]***	7.263[0.00]***	6.650[0.00]***
CO_2 = f (PD, GDPPC, EE, STPC)			
DHg	6.569[0.00]***	6.699[0.00]***	5.971[0.00]***
DHp	7.264[0.00]***	7.468[0.00]***	6.892[0.00]***
CO2 = f (PD, GDPPC, EE, SMGDP)			
DHg	6.995[0.00]***	7.237[0.00]***	6.648[0.00]***
DHp	7.428[0.00]***	7.782[0.00]***	7.109[0.00]***
CO2 = f (PD, GDPPC, EE, STGDP)			
DHg	6.782[0.00]***	6.884[0.00]***	6.625[0.00]***
DHp	6.957[0.00]***	7.326[0.00]***	6.583[0.00]***
CO2 = f (PD, GDPPC, EE, STTOR)			
DHg	6.439[0.00]***	6.704[0.00]***	6.285[0.00]***
DHp	6.885[0.00]***	7.135[0.00]***	6.593[0.00]***

Notes: p-values are reported in brackets. The criterion used in this paper is $IC_2(K)$ with the Maximum number of factors (K) set equal to 5. For the bandwidth selection, M was chosen to represent the largest integer less than $4(T/100)^{2/9}$, as suggested by Newey and West (1994). *** indicates the rejection of null hypothesis of no co-integration at the 1% level of significance.

Table 6: Common correlated effects mean group (CCE-MG) long-run estimates

Variables	Full sample	Developed economies	Emerging economies
	Coefficient	Coefficient	Coefficient
CO_2 = f (PD, GDPPC, EE, SMPC)			
PD	-0.312 [0.00]***	-0.841 [0.00]***	0.021 [0.00]***
GDPPC	1.128 [0.00]***	1.014 [0.00]***	1.139 [0.00]***
EE	1.167 [0.00]***	1.186 [0.00]***	1.059 [0.00]***
SMPC	0.044 [0.00]***	-0.025 [0.00]***	0.068 [0.00]***
		Wald F-test = [0.00]	
CO_2 = f (PD, GDPPC, EE, STPC)			
PD	-0.469 [0.00]***	-0.783 [0.00]***	0.064 [0.00]***
GDPPC	1.152 [0.00]***	1.014 [0.00]***	1.172 [0.00]***
EE	1.156 [0.00]***	1.215 [0.00]***	1.051 [0.00]***
STPC	-0.012 [0.00]***	-0.016 [0.00]***	0.018 [0.00]***
		Wald F-test = [0.00]	
CO2 = f (PD, GDPPC, EE, SMGDP)			
PD	-0.428 [0.00]***	-0.719 [0.00]***	0.055 [0.00]***
GDPPC	1.057 [0.00]***	1.028 [0.00]***	1.093 [0.00]***
EE	1.085 [0.00]***	1.196 [0.00]***	1.037 [0.00]***
SMGDP	-0.026 [0.00]***	-0.039 [0.00]***	0.019 [0.00]***
		Wald F-test = [0.00]	
CO2 = f (PD, GDPPC, EE, STGDP)			
PD	-0.436 [0.00]***	-0.744 [0.00]***	0.063 [0.00]***
GDPPC	1.068 [0.00]***	1.042 [0.00]***	1.112 [0.00]***
EE	1.102 [0.00]***	1.216 [0.00]***	1.073 [0.00]***
STGDP	-0.032 [0.00]***	-0.041 [0.00]***	0.025 [0.00]***
		Wald F-test = [0.00]	
CO2 = f (PD, GDPPC, EE, STTOR)			
PD	-0.458 [0.00]***	-0.782 [0.00]***	0.079 [0.00]***
GDPPC	1.091 [0.00]***	1.085 [0.00]***	1.135 [0.00]***
EE	1.129 [0.00]***	1.273 [0.00]***	1.098 [0.00]***
STTOR	-0.041 [0.00]***	-0.053 [0.00]***	0.032 [0.00]***
		Wald F-test = [0.00]	

Notes: p-values are reported in brackets. The Wald F-test investigates the restriction of the equality of the stock market coefficients across the developed and emerging country samples. .*** indicates the significance level at 1%.

Table 7: Common correlated effects mean group (CCE-MG) long-run estimates

(with squared stock market indicators)

Variables	Full sample	Developed economies	Emerging economies
	Coefficient	Coefficient	Coefficient
CO_2 = f (PD, GDPPC, EE, $SMPC^2$)			
PD	-0.286 [0.00]***	-0.314 [0.00]***	0.028 [0.00]***
GDPPC	1.107 [0.00]***	1.011 [0.00]***	1.134 [0.00]***
EE	1.124 [0.00]***	1.165 [0.00]***	1.051 [0.00]***
$SMPC^2$	-0.007 [0.00]***	-0.009 [0.00]***	0.010 [0.00]***
		Wald F-test = [0.00]	
CO_2 = f (PD, GDPPC, EE, $STPC^2$)			
PD	-0.428 [0.00]***	-0.796 [0.00]***	0.058 [0.00]***
GDPPC	1.073 [0.00]***	1.006 [0.00]***	1.159 [0.00]***
EE	1.119 [0.00]***	1.235 [0.00]***	1.014 [0.00]***
$STPC^2$	-0.006 [0.00]***	-0.005 [0.00]***	-0.006 [0.00]***
		Wald F-test = [0.00]	

CO2 = f (PD, GDPPC, EE, $SMGDP^2$)			
PD	-0.409 [0.00]***	-0.758 [0.00]***	0.047 [0.00]***
GDPPC	1.036 [0.00]***	0.092 [0.00]***	1.116 [0.00]***
EE	1.092 [0.00]***	1.157 [0.00]***	0.086 [0.00]***
$SMGDP^2$	-0.005 [0.00]***	-0.003 [0.00]***	-0.005 [0.00]***
		Wald F-test = [0.00]	
CO2 = f (PD, GDPPC, EE, $STGDP^2$)			
PD	-0.424 [0.00]***	-0.699 [0.00]***	0.042 [0.00]***
GDPPC	1.058 [0.00]***	0.108 [0.00]***	1.139 [0.00]***
EE	1.117 [0.00]***	1.135 [0.00]***	0.097 [0.00]***
$STGDP^2$	-0.008 [0.00]***	-0.006 [0.00]***	-0.007 [0.00]***
		Wald F-test = [0.00]	
CO2 = f (PD, GDPPC, EE, $STTOR^2$)			
PD	-0.409 [0.00]***	-0.671 [0.00]***	0.038 [0.00]***
GDPPC	1.036 [0.00]***	0.087 [0.00]***	1.114 [0.00]***
EE	1.085 [0.00]***	1.119 [0.00]***	0.076 [0.00]***
$STTOR^2$	-0.005 [0.00]***	-0.004 [0.00]***	-0.006 [0.00]***
		Wald F-test = [0.00]	

Notes: p-values are reported in brackets. The Wald F-test investigates the restriction of the equality of the stock market coefficients across the developed and emerging country samples.*** indicates the significance level at 1%.