Globalization-Emissions Nexus: Testing the EKC hypothesis in Next-11 Countries

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Abstract: This study investigates the association between globalization and carbon emissions for N-11 countries. In doing so, we apply bounds testing approach to examine cointegration between globalization and CO_2 emissions. The results confirm the U-shaped association between globalization and carbon emissions for Bangladesh, Iran, and South Korea. Contrarily, traditional approach validates an inverted-U relationship between globalization and carbon emissions for Pakistan and South Korea, but U-shaped relationship exists for the Philippines and Vietnam. The presence or absence of an inverted-U relationship between globalization and carbon emissions has important policy implications using globalization as an economic tool for sustainable economic development.
Keywords: Globalization, Emissions, EKC, N-11

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1. Introduction

Globalization is widely understood in terms of helping firms, individuals, and economies to expand their outsourcing business, mitigating migration, and trading goods and services at the global level. In other words, globalization connects all developing and developed economies in sharing their cultural and public policies. It benefits all economies in advancing the process of growth and development, which is required to solve the rising problems of income inequality, poverty, and unemployment. In addition to environmental consequences, globalization is found to have affected all countries significantly. For instance, as the need for economic growth intensifies in an economy, energy consumption increases. The process of achieving growth via energy consumption, industrialization, and urbanization also results in carbon dioxide (CO_2) emissions, which damages environmental quality. Increased loss of environmental quality causes climate change and ecological crises. Taken together, ecological crises and imbalances affect socio-economic life of people in society (Shahbaz et al. 2015a).

Moreover, the role of globalization on CO_2 emissions has been considered an important issue in the field of applied energy since 1970, and has established much empirical regularity within specific time series and panel data frameworks (Christmann and Taylor 2001). This is also indicative of an increasing trend in global warming and climate change, the consequences of which have been felt in society in the form of deforestation, rising sea levels, loss of biodiversity, unusual wind patterns, rainfall, and/or droughts, and massive crop failures (Hawken et al. 2008). Such ecological imbalances have become a challenging concern for academics, governments, and policymakers around the world (Panayotou 1997). The proponents of globalization claim that it is not harmful for a country because it contributes to better environmental quality by lowering CO_2 emissions (Christmann and Taylor 2001, Shin 2004, Lee and Min 2014, Ling et al. 2015, Shahbaz et al. 2015b). However, the opponents of globalization claim that it is harmful because it causes deterioration in the quality of environment by increasing CO_2 emissions (Copeland and Taylor 2004, Friedman 2005, Wijen and Van Tulder 2011, Aichele and Felbermayr 2012, Shahbaz et al. 2015a). They further argue that globalization stimulates economic activity at the cost of environmental quality if the techniques of production and consumption are kept unchanged. Last, but not least, globalization boosts economic development, particularly in developing economies, but also accelerates natural resource depletion and environmental devastation (Fridun 2005, Wijen and Van Tulder 2011).

In a similar fashion, Panayotou (1997), an opponent of globalization, argues that newly industrialized and developing countries are more polluted today than they were 40 to 45 years ago, compared with developed countries. Although the theoretical understanding between globalization and environmental quality appears to be ambiguous, it is clear that developed countries have raised concerns over the pollution-intensive industries of developing countries. This is because "dirty" industries have damaged environmental quality at the same time as producing higher output in many such economies. This scenario has also been evidenced by the recent report of the World Resource Institute's CAIT Climate Data Explorer (WRI, 2014). The phenomenon has mainly occurred owing to the significant shifts in their open economic policies (Panayotou 1997, Baek et al. 2009). The loss of environmental quality arises mainly in developing nations owing to their weak enforcement of environmental rules and regulations and lax compliance of pollution-intensive firms in their production activities. This implies that globalization favors the growth of pollution-intensive industries in developing countries, causing a significant adverse effect on environmental quality, whereas developed countries tend to protect environmental quality by enforcing strict environmental regulations (Copeland and Taylor 1994, 2004, Copeland 2005). This further implies that higher economic growth, increasing energy consumption, and looser standards of environmental regulations in developing countries are the root causes of environmental degradation. In contrast, developed countries enforce strict environmental regulations in order to enhance environmental quality, which is necessary to ensure sustainable economic development in the long run (Dean 2002, Copeland 2005, Baek et al. 2009, Shahbaz et al. 2015a).

Examining the association between globalization and CO_2 emissions is of primary interest because it permits policy designers to observe the response of globalization on environmental quality. Globalization's effect on environmental quality is a crucial issue because the prime objective of an economy is to attain sustainable economic development, using globalization as a long-term economic tool. There are two strands available in the existing literature on the association between globalization and carbon emissions. The first strand addresses the globalization-emissions nexus using time series for individual countries (see, inter alia, Dean 2002, Baek et al. 2009, Shahbaz et al. 2015a, b, 2016, 2017). The second strand of research includes the works of Leamer (1988), Lucas et al. (1992), Copeland and Taylor (1994, 2004), Copeland (2005), Chintrakarn and Millimet (2006), Managi et al. (2008, 2009), Löschel et al. (2013), Naughton (2014), Shahbaz et al. (2016), and Paramati et al. (2017), who have examined the relationship between globalization and carbon emissions using various indicators of globalization in cross-sectional or country panel data. Similarly, a U-shaped or inverted-U-shaped association between globalization and emissions is not free from criticism. The inverted-

U-shaped relationship between globalization and carbon emissions is termed the EKC (environmental Kuznets curve), which reveals that globalization initially aligns with CO_2 emissions, but then starts to improve environmental quality by lowering carbon emissions at later stages of economic development. The U-shaped association between globalization and emissions implies that globalization improves environmental quality initially, but after a certain level, the quality begins to degrade.

Perman and Stern (2003) and, later, Stern (2004) noted that empirical investigation of the EKC hypothesis is econometrically weak. We argue that modeling emissions is a function of globalization, and augmenting it by incorporating globalization-squared or globalization-cubed variables offers a specification problem because of the presence of multi-colinearity between the variables (Copeland 2005, Chintrakarn and Millimet 2006, Managi et al. 2009, Naughton 2010, Löschel et al. 2013). Thus, our first contribution to the existing literature lies in interpreting results. The correlation test is applied to examine the correlation between globalization–globalization-squared and globalization–globalization-cubed to confirm if colinearity or multi-colinearity exists. We find that the correlation coefficients for globalization–globalization-squared are 0.9989 (Bangladesh), 0.9998 (Egypt), 0.9996 (Indonesia), 0.9997 (Iran), 0.9999 (Mexico), 0.9997 (Nigeria), 0.9997 (Pakistan), 0.9996 (Philippines), 0.9995 (South Korea), 0.9997 (Turkey), and 0.9994 (Vietnam). The correlation coefficient between globalization-squared and globalization-cubed are 0.9990, 0.9998, 0.9997, 0.9940, 0.9999, 0.9999, 0.9996, 0.9991, 0.9997, 0.9998, and 0.9994 for Bangladesh, Egypt, Indonesia, Iran, Mexico, Nigeria, Pakistan, Philippines, South Korea, Turkey, and Vietnam, respectively. The high correlation of the globalization–globalization-squared nexus validates the presence of colinearity between globalization and globalization-squared. The second contribution to the existing literature is to suggest an alternative method of examining whether developing economies, such as the N-11 countries, have condensed carbon emissions using globalization as an economic tool over time.

The rationale to choose the N-11 countries is manifested in the fact that these are the economies with enormous potential output contributions to global economic activity as well as energy demand and CO_2 emissions. The prima facie evident significance of the N-11 countries for the global economy implies that they have a nontrivial influence on the implementation of environmental policies and decisions. In this regard, the N-11 are comparable with the BRIC (Brazil, Russia, India, and China) economies which have analogously demonstrated a remarkable growth in their share of global trade accompanied by the financial openness and economic growth. Despite the fact that the N-11 are facing immense challenges, it is intuitive to expect that the N-11 economies may grow faster than their counterparts and major market economies. As a series of steps towards a long term and sustainable economic developed, the N-11 countries have initiated wide economic reforms. For instance, Nigeria has been focusing on tackling corruption, Turkey has endeavored to avail European Union membership while the improvement of corporate law, tax collection and financial reforms have been the focus on Pakistani governments.

On a broader note, all the N-11 countries with their rapid economic growth, trade openness and financial development as made them increase their share in global economic and financial system. Of course, Iran is an exception due to economic sanctions by the US and EU which has constraint its economy. As a result of the rapid industrialisation and increased investment, N-11 countries are also experiencing increased energy demand. The contextual factors, accompanied by the deployment of technologies not very efficient raises environmental and ecological concerns. To tackle these concerns, countries like Nigeria and Mexico have incentivised the firms to use more energy efficient technologies which can enhance productivity as well as reduce CO_2 emissions. The developments and statistics of the last few years suggests that N-11 was contribution 7% to the global GDP in 2007 with 9% as their proportion to the world energy demand and 9% share in global annual CO_2 emissions (Sachs, 2007), however, energy consumption has increased its share to 11% (Yildirim et al. 2014) which is resulting in higher share of global CO_2 emissions. According to the projections by Sachs (2007), GDP of N-11 countries could increase to 2/3rd of the G7 countries by 2050. While this indicates the increasing significance of the N-11 countries in economic and political terms, but it is also a clear manifestation of their global environmental footprint and contributions to global emissions. We can see this by comparing long-run and short-run globalization elasticities. Globalization leads to less CO_2 emissions over time if short-run globalization elasticity is greater than the elasticity of globalization in long run. This further confirms the presence of EKC between globalization and carbon emissions, and reveals that the association between the variables is an inverted-U shaped. If long-run globalization elasticity is more than the elasticity of globalization in short run, globalization increases carbon emissions over time, and reveals that the relationship between globalization and carbon emissions is U-shaped. The third contribution to the existing literature, following Brown and McDononugh (2016), is an application of the ARDL bounds-testing approach developed by Pesaran et al. (2001) to test whether globalization and carbon emissions are cointegrated. Brown and McDononugh (2016) argued that investigating the EKC phenomenon between globalization and carbon emissions is meaningless without cointegration between the variables. The fourth contribution is to apply the innovative accounting approach (the combination of a variance decomposition analysis and the impulse response function) to examine the direction of causal association between globalization and carbon emissions. Lastly, we investigate the EKC hypothesis between globalization and carbon emissions in the case of N-11 countries. Our results indicate the presence of cointegration between globalization and carbon emissions in all sampled countries, except the Philippines. The empirical evidence of the relationship between globalization and CO_2 emissions reveals it is either an inverted-U or U-shape, and is sensitive to empirical methods applied. A causality analysis reveals the unidirectional causality from globalization to CO_2 emissions in Egypt, Indonesia, and Turkey. Furthermore, CO_2 emissions cause globalization in Iran, Nigeria, Pakistan, the Philippines, and South Korea, while a neutral effect also exists between globalization and carbon emissions in Mexico.

2. Literature Review

Given the presence of mixed findings on the dynamics of environmental quality, the existing literature shows that energy-related researchers still need to find a concrete and policy-enhancing relationship between economic growth and environmental degradation. Such a relationship is warranted because it informs policymakers of developing countries in the process of augmenting their energy emission functions. Motivated by the spirit of such urgency, Kraft and Kraft (1978) provided a causal relationship between energy consumption and economic growth. Subsequently, Grossman and Krueger (1991, 1995) established a debatable relationship between environmental degradation and economic growth via an inverted U-shaped environmental Kuznets curve

(EKC).[1] However, efforts by advanced and developing countries to excel in terms of economic growth and development have kept environmental quality protection as a secondary goal in climate policymaking. Such attitudes toward environmental quality have led to serious debate over the environmental consequences of economic growth and trade openness, which has threatened the balance between their sustainable development and ecological future. In response, many developed and developing countries have started enacting and implementing environmental policies to minimize the environmental consequences of economic growth and trade openness. As a result, the stringency of these environmental regulations has increased over the years and increased awareness of the problems (Jena and Grote, 2008). In light of such a debatable issue, it has been observed that both developed and developing countries are now competing at greater levels by opening their economies and preferring greater trade openness. Both developing and developed countries' beliefs reveal that a greater integration of economies and societies can be enhanced only via globalization (Agénor, 2003). Heckscher (1919) and Ohlin (1933) further argue that "trade being an engine of economic growth in general, provides an innovative opportunity to enhance the process of production as well as productivity of abundant natural resources at the micro level". Furthermore, international trade in the face of globalization mobilizes factors of production freely among countries, allowing all countries to benefit economically, subject to their comparative advantage. Greater economic integration and trade openness are acknowledged as primary sources of economic development.

[1]The EKC hypothesis can be understood by linking the relationship between environmental quality and economic growth in the course of economic development. Environmental quality first deteriorates and then improves as economies grow (Kuznets, 1955). Our reading of this hypothesis further suggests that after a certain level of income, stimulating environmental quality is becoming a matter of concern among people and governments owing to their greater awareness and better institutional quality.

Considering the economic benefits of trade openness, Grossman and Krueger (1991) and Copeland and Taylor (2004) argue that trade openness can influence environmental quality both positively and negatively. Grossman and Krueger (1991) further argue that economic policies are the main reason for establishing a relationship between environmental quality and trade openness, irrespective of countries' size and development levels. This also produces two contrasting views on the environmental impacts of trade openness. The proponents of trade openness postulate that it provides an opportunity for countries to access the international trading market and to obtain comparative benefits in the course of exporting and importing factors of production. In addition to the production efficiency gained, international trade also enables participating countries to address the effective management of scarce resources. Trade openness provides opportunities to most countries to scale their sustainable environmental quality by lowering CO_2 emissions by importing and using green-driven technologies in production and consumption activities (Runge 1994, Helpman 1998). Jayadeappa and Chhatre (2000) describe that trade enhances inclusive economic development. As a result, people with greater disposable income can manage environmental quality effectively by investing in imported green technology for the purpose of economic activities. Eventually, such technology can be disseminated across the consumption and business activities of an economy. Moreover, fiscal governments with higher economic growth can import environment-friendly production and consumption technologies. With the help of such technologies, governments can better assess the efficiency of environmental concerns, which seems to be a necessary condition for future inclusive and sustainable economic development.

However, few studies argue for a win-loss position; although it is rare for advanced countries, it seems to occur regularly in developing countries. This is because trade openness scales inclusive economic development for developing nations and brings with it detrimental changes to their long-term environmental quality (Copeland and Taylor 1995, 2004, 2005, Christmann and Taylor 2001). Then, the pollution haven hypothesis states that heavy polluting industries migrate from developed countries, with their stringent environmental policies, to developing countries, which have lax environmental regulations. As a consequence, the cost of production by dirty industries in developing countries is low owing to the lack of effective implementation of environmental regulations. This results in growing levels of pollution in developing countries over time. These dirty industries, which are the cause of pollution activities, produce and export the same items to the developed countries. In this case, developed countries are able to have a cleaner home environment by importing pollution-content products, and thereby, helping them to achieve a higher quality of life in the long run.

However, both nature's household (ecology) and human kind's household (economics) have been adversely affected by transnational environmental problems. These include ozone depletion, global warming and climate change, deforestation and acid rain, all of which have cross-border effects. These problems have adverse effects on all countries. This shows that both developed and developing countries are the root cause of environmental problems that we are experiencing today. As a consequence, developed countries cannot sustain a high quality of life given the problems of global warming and climate change. This further indicates that the nature of economic growth and development created by multinational firms in developing countries is not environment friendly (Copeland and Taylor 2003, 2004). In a similar vein, other studies

(Shahbaz et al. 2012, Schmalensee et al. 1998, Chaudhuri and Pfaff 2002) argue that international trade is the cause of natural resource depletion, both in developed and developing economies, adding to CO_2 emissions and impeding the quality of environment.

Influenced by the role of trade openness on the evolution of energy consumption, recent studies have examined the causal linkage between globalization and environment for a single country or for a panel framework. For instance, empirical studies examine the impacts of traditional and modern globalization indicators on environmental quality for various countries (Machado 2000, Antweiler et al. 2001, Christmann and Taylor 2001, Shin 2004, Managi 2004, Managi and Jena 2008, Chang 2012, Shahbaz et al. 2012, Kanzilal and Ghosh 2013, Shahbaz et al. 2013, Tiwari et al. 2013, Ling et al. 2015, Lee and Min 2014, Shahbaz et al. 2015a, b, 2016). However, few studies have empirically investigated the causal linkage between trade openness and CO_2 emissions, and the findings of those that have are conflicting (Shahbaz et al. 2013, Ling et al. 2015, Ahmed et al. 2016). While examining the effect of trade openness on environmental quality, Antweiler et al. (2001) introduced composition, scale, and technological effects by decomposing the trade model of carbon emissions. They argue that a beneficial effect of trade on environment exists if the technological effect is greater than both the composition and the scale effects. With the help of their pollution-haven hypothesis, Copeland and Taylor (2003, 2005) also support international trade as being highly beneficial to environmental quality through the enforcement of strong environmental regulations. For instance, free trade reduces CO_2 emissions in developed countries by shifting their dirty industries to developing nations through the imposition of strong environmental regulations. Using panel data for the period 1960–1999 for 63 developed and developing countries, Managi (2004) finds a positive impact of trade openness on CO_2 emissions. Using survey data, Shin (2004) finds that trade openness is not impeding the quality of environment in Chinese cities. McCarney and Adamowicz (2006) also take the view that trade openness improves the quality of environment, depending on the nature of government policies. Similarly, Managi et al. (2008) find that environmental quality is improved if environmental regulations are implemented effectively. In contrast, Frankel and Rose (2005) argue that trade openness reduces CO_2 emissions through stronger environmental regulations. Moreover, in their findings, Jena and Grote (2008) argue that although the impact of trade liberalization is not unique across pollutants, trade liberalization improves the quality of environment by lowering CO_2 and NO_2 emissions for industrial cities in the Indian economy. Dinda (2006) notes that the impact of globalization on carbon emissions depends on the fundamental properties of an economy and its dominating role of comparative advantages. These empirical results indicate a positive effect of globalization on CO_2 emissions.

Baek et al. (2009), in their study examining the consequences of trade liberalization on the quality of environment for developed and developing countries, confirm the environmental Kuznets curve hypothesis and the pollution-haven hypothesis. They further find that trade liberalization is beneficial for developed countries because it increases their environmental quality, whereas it is not beneficial for developing countries because of its detrimental effect on the quality of their environment. They further find a unidirectional causality from trade openness to SO_2 emissions, particularly for developed economies, indicating that any change in trade openness causes a consequential change in SO_2 emissions. Moreover, a unidirectional causality from SO_2 emissions to trade openness is identified for most developing economies, indicating that any change in the quality of environment causes a consequential change in trade openness.

With reference to single-country studies, Saboori et al. (2012) find that trade openness is not the prime contributing factor to the dynamics of environment in Malaysia, whereas Solarin (2014) concludes that Malaysia's exports to Singapore have a positive correlation with CO_2 emissions. Löschel et al. (2013) investigate the association between globalization and environmental quality using the World Input Output Database (WIOD) for 40 countries. They find that the stimulation of trade increases energy intensity, which, as a result, leads to CO_2 emissions and degrades environmental quality. Similarly, Ling et al. (2015) find that trade openness benefits the environment in Malaysia by lowering CO_2 emissions. This finding is also consistent with result of Cole et al. (2011) that the environmental effect of trade openness depends on the type of pollutants concerned. Furthermore, Machado (2000) finds a positive association between foreign trade and CO_2 emissions in Brazil. Shahbaz et al. (2012) find a reduction in CO_2 emissions as an effect of trade openness in Pakistan. Shahbaz et al. (2013) also find that trade openness reduces CO_2 emissions in Indonesia. Similarly, Kanzilal and Ghosh (2013) find a beneficial effect of trade openness on environmental quality in India by reducing CO_2 emissions. In contrast, Tiwari et al. (2013) examine the dynamic causal relationship between trade openness and CO_2 emissions for India, and find a significant effect of trade openness adding to CO_2 emissions.

It is essential to review the existing literature on the impact of the newly developed globalization index on CO_2 emissions using time series and panel frameworks. Using survey data for China, Christmann and Taylor (2001) find that globalization is not detrimental to environmental quality. They also argue that Chinese firms' international exposure has largely helped the Chinese economy to improve its environmental quality through the effective implementation of environmental regulations. This shows that environmental quality is enhanced in the presence of

Chinese firms' self-regulation. Subsequently, using a larger annual panel data set of both developed and developing countries in a panel framework, Lee and Min (2014) find that globalization improves environmental quality by significantly reducing CO_2 emissions. Shahbaz et al. (2015), in an empirical investigation, find a positive effect of globalization on CO_2 emissions, indicating that globalization is not beneficial to the Indian economy because it weakens the quality of the environment. In contrast, Shahbaz et al. (2017c) find a beneficial effect of globalization on environment in Australia because it lowers CO_2 emissions. This indicates that environmental quality in Australia is being achieved as a result of globalization. Paramati et al. (2017) investigate the association between globalization and carbon emissions using political globalization as an indicator of globalization. They noted that political globalization reduces carbon emissions and improves the quality of environment. For the Chinese economy, Shahbaz et al. (2017) applied an augmented carbon emissions function by incorporating globalization (economic, social, and political) to examine its impact on environmental quality. They found cointegration between the variables, and that globalization is environment friendly. Their empirical analysis also reports a unidirectional causality from globalization (economic, social, and political) to carbon emissions.[2]

From the above discussion of the existing literature, we find that most studies use trade openness as a narrowly defined indicator of globalization while examining the role of globalization on CO_2 emissions using the carbon emissions function. This has led to mixed and inconclusive empirical findings, indicating that globalization is beneficial for some countries, but not beneficial for

[2]Shahbaz et al. (2017b) use trade openness as an indicator of globalization, and examine the association between globalization and CO_2 emissions. They noted that globalization (trade openness) makes a positive contribution to environmental degradation in global high-, middle-, and low-income countries.

others. As a result, the findings that emerge from single-country studies or from panel studies cannot be generalized to other countries. Thus, using trade openness has a core limitation because it only covers trade intensity. To overcome these emerging issues in the fields of ecological and applied energy economics, Dreher's (2006) widely defined globalization index might be ideal, because it covers three aspects of globalization (i.e., economic, political, and social) while investigating its role in the evolution of CO_2 emissions using the carbon emissions function, given that so few studies have recognized globalization as an environmental quality-inducing factor affecting CO_2 emissions (Lee and Min 2014, Shahbaz et al. 2015a, b). Given the existing gap in the literature, our study investigates the role of globalization on CO_2 emissions in the carbon emissions functions of Next-11 countries. The prime motivation behind this study is the absence of empirical research into this issue for these countries. Finally, considering the potential role of globalization on CO_2 emissions in carbon emissions function of Next-11 countries will offer new policy insights to their policymakers and fiscal governments when formulating comprehensive environmental policies and assessing the quality of their environment.

3. The Model, Methodological Framework, and Data

Whether the relationship between globalization and carbon emissions has a U-shape or inverted-U-shape is the main research question of this study, using data of N-11 countries for the period 1972–2015. A few existing studies have investigated the association between globalization and CO_2 emissions, including Baek et al. (2009), Managi et al. (2009), Naughton (2010), Löschel et al. (2013), Shahbaz et al. (2015a, b,) and Paramati et al. (2017), but their findings have proved inconclusive on the nature of the EKC patterns between the two variables. This study provides an alternative way to estimate whether the relationship between globalization and carbon emissions has a U-shaped or an inverted-U shaped. The general form of carbon emissions function is as follows:

$$C_t = f(G_t). \quad (1)$$

We transform the globalization and carbon emissions series into logarithmic form. The log-linear specification provides efficient empirical results compared to a simple linear specification. The empirical equation of the log-linear specification is given as follows:

$$\ln C_t = \alpha_0 + \alpha_G \ln G_t + \mu_i, \quad (2)$$

where $\ln C_t$, $\ln G_t$, and μ_i are the natural log of carbon emissions, natural log of globalization, and an error term, respectively and all assumed to be normally distributed. In conventional econometrics, we find various approaches to examine whether cointegration exists between the variables. Numerous popular approaches have been employed to investigate the long-run linkages between variables, including Engle-Granger's (1987) residual-based bivariate cointegration test, the bivariate and multivariate maximum likelihood tests, the approach of Johansen and Juselius (1990), the fully modified ordinary least squares method (FMOLS) developed by Philips and Hansen (1990), and Stock and Watson's (1993) dynamic ordinary least squares (OLS) approach (i.e., leads and lags dynamics). These cointegration tests are not eligible for small data sets with a mixed order of integration among the variables (Shahbaz et al. 2015a, b). Moreover, if we use these techniques, we may have less robust findings, which may mislead us when trying to formulate appropriate environmental policy using globalization as a potential variable in the carbon emissions function. To avoid such issues, we have chosen the autoregressive distributed lag model (ARDL) bounds testing approach developed by Pesaran et al. (2001) to test for cointegration among the series. Here, we use the unrestricted error correction model (UECM) version of the bounds testing approach to cointegration, which is modeled as follows:

$$\Delta \ln C_t = \alpha_1 + \alpha_t T + \alpha_2 \ln C_{t-1} + \alpha_3 \ln G_{t-1} + \sum_{i=1}^{m} \beta_1 \Delta \ln C_{t-1} + \sum_{i=0}^{m} \beta_2 \Delta \ln G_{t-1} + \mu_i , \qquad (3)$$

where Δ is the difference in terms, α_2 and α_3 represent the long-run relationship, β_1 and β_2 show the short-run dynamics, and μ_i is the error term. The bounds-testing approach examines whether cointegration is present if variables are integrated at I(0) or I(1), or I(0)/I(1). In doing so, we compute the ARDL F-statistic by applying the joint significance of the lagged-level parameters. In equation 3, $\Delta \ln C_t$ is the dependent variable, and the null hypothesis of no cointegration is $H_0 : \alpha_2 = \alpha_3 = 0$, against the alternative hypothesis of cointegration (i.e., $H_a : \alpha_2 \neq \alpha_3 \neq 0$). We compare the computed ARDL F-statistic, where the lower and upper critical bounds generated by Narayan (2005) are suitable for small samples, such as 30–80 observations, at different lag lengths. The critical bounds (lower and upper) tabulated by Pesaran et al. (2001) are suitable for longer samples, and have a non-standard distribution for small samples. We may accept the hypothesis in favor of cointegration between the variables if the computed ARDL F-statistic is more than the upper critical bound because this means the variables are integrated at I(1) or at a mixed order of integration. If the computed ARDL F-statistic is smaller than the lower critical bounds, then we may accept the hypothesis of no cointegration between globalization and carbon emissions. The decision of cointegration between the variables is inconclusive if the computed ARDL F-statistic lies between the lower and upper critical bounds. We conduct a diagnostic analysis to test for the presence of a normal distribution in the data, the absence of serial correlation, autoregressive conditional heteroskedasticity, white heteroskedasticity, and a good specification of the ARDL empirical equation. The reliability of the ARDL estimates is investigated by applying CUSUM and CUSUMSQ tests.

This study covers the period 1972–2015. The *World Development Indicators* (CD-ROM, 2016) are used to collect data on CO_2 emissions (metric tons), which are later converted into per capita units by dividing the variable by total population. The overall globalization index as an influential variable in the dynamics of carbon emissions in the context of Next-11 countries is sufficient. In doing so, the globalization index estimated by Dreher (2006) is suitable for this empirical analysis. Fundamentally, Dreher (2006) separates the overall globalization index into three sub-indices: economic globalization, social globalization, and political globalization. Economic globalization is composed of actual economic flows that include trade, foreign direct investment, portfolio investment, and restrictions on trade and capital flows (e.g. restrictions on trade and capital using hidden import barriers, mean tariff rates, taxes on international trade as a share of current revenue, and an index of capital controls). Social globalization comprises personal contacts, telephone contacts, tourism, the migration of people among countries, information flows (internet usage, televisions per 1,000 people, trade in newspapers), and data on cultural proximity (number of McDonald’s restaurants, number of IKEA stores, trade in books). Political globalization includes the number of embassies in a country, membership of international organizations, and participation in the UN Secretary Council and international treaties. Taken together, the relative share in the overall globalization index contributed by economic globalization is 36%, that of social globalization is 38%, and that of political globalization is 26%. The overall globalization index and its sub-indices are available at http://globalization.kof.ethz.ch/.

4. Interpretation and Discussion of Results

Table-1 explains the descriptive statistics. Note that globalization has a normal distribution (i.e., the distribution is bell-shaped) in all countries. CO_2 emissions are normally distributed in Bangladesh, Egypt, Indonesia, Iran, Mexico, Nigeria, Turkey, South Korea, and Vietnam, but are not normally distributed in the case of the Philippines. Globalization has less volatility compared to other countries, and Vietnam has high volatility in CO_2 emissions. These findings are not unusual.

Table-1: Descriptive Statistics

Variable	Statistics	Bangladesh	Egypt	Indonesia	Iran	Mexico	Nigeria	Pakistan	Philippines	Turkey	South Korea	Vietnam
Globalization	Mean	3.1855	3.8005	3.7171	3.4113	3.9439	3.7500	3.6092	3.7964	3.9367	3.8510	3.3759
	Median	3.1622	3.8626	3.7312	3.3160	4.0344	3.7772	3.6099	3.8371	4.0427	3.9498	3.2999
	Maximum	3.7816	4.0913	4.0691	3.7784	4.1247	4.0189	3.9902	4.0773	4.2705	4.1705	3.9560
	Minimum	2.5710	3.3921	3.1646	3.0549	3.7101	3.3690	3.2737	3.3582	3.5192	3.3210	2.9295
	Std. Dev.	0.4126	0.2228	0.2830	0.2407	0.1523	0.1878	0.2708	0.2352	0.2742	0.2922	0.3675
	Skewness	0.0120	-0.2223	-0.1266	0.1500	-0.4302	-0.3148	0.0428	-0.3773	-0.3114	-0.3105	0.2105
	Kurtosis	4.0865	1.4837	1.4458	1.4204	1.5282	1.9608	1.3038	1.8091	1.4783	1.5348	1.4458
	Jarqu-Bera	0.1296	4.5773	4.5457	3.9854	5.3286	2.7067	5.2876	3.6441	4.9561	4.6429	4.7533
	Probability	0.1963	0.1014	0.1030	0.1363	0.0696	0.2583	0.0710	0.1616	0.0839	0.0981	0.0928
CO_2 Emissions	Mean	-1.8053	0.3967	0.0005	1.5945	1.2649	-0.4627	-0.5061	-0.2419	1.0124	1.8218	-0.5023
	Median	-1.8342	0.3590	0.1192	1.5092	1.3053	-0.4059	-0.4193	-0.1979	1.0204	2.0139	-0.7683
	Maximum	-0.7950	1.0193	0.6688	2.0608	1.4566	0.0069	-0.0311	-0.0225	1.6650	2.6435	0.8412
	Minimum	-2.9747	-0.4872	-1.0181	1.0274	0.8538	-1.1330	-1.1949	-0.6610	0.3897	0.5882	-1.3081
	Std. Dev.	0.6154	0.4447	0.4931	0.3446	0.1322	0.2969	0.3770	0.1575	0.3528	0.5796	0.6957
	Skewness	-0.0027	-0.3484	-0.3532	-0.0264	-1.6361	-0.6601	-0.4106	-1.0345	-0.0246	-0.4814	0.6326
	Kurtosis	1.8583	2.1898	2.0594	1.5108	5.2108	2.5761	1.8712	3.4427	1.9513	2.0136	1.9300
	Jarqu-Bera	2.3893	2.0939	2.5371	3.4231	2.5919	3.5256	3.5726	8.2083	2.0206	3.4832	5.0340
	Probability	0.3027	0.3509	0.2812	0.1805	0.2134	0.1715	0.1675	0.0165	0.3640	0.1752	0.0806

To test the validity of the cointegration association between the variables by applying the bounds-testing approach to cointegration, it is necessary to test the unit root properties of the variables. Although we can apply the bounds-testing approach if the variables are stationary (i.e., I(0)), first difference (i.e., I(1)), or the order of integration is mixed (i.e., I(0)/I(1)), we must make sure that none of the variables are integrated at I(2). The bounds testing approach to cointegration is invalid if any variable is stationary at I(2). Here, we apply the ADF unit root tests to examine the integrating properties of globalization and CO_2 emissions. The results are reported in Table-2. Note that globalization and CO_2 emissions show a unit root problem at the level considering the intercept and the trend for N-11 countries, which is confirmed by the ADF unit root test. Globalization and CO_2 emissions are found to be stationary at the first difference. The empirical results provided ADF unit root test are ambiguous as ADF unit root test does not accommodate information of unknown structural break in the series (Narayan and Pop, 2010, 2013). This issue is solved by applying ADF unit root test accommodating single unknown structural break in the series of globalization and carbon emissions. This test is developed by Kim and Perron (2009) and empirical results are shown in Table-2. We find that all the variables have unit root problem in the presence of structural break in the series. After first difference, globalization and carbon emissions are found stationary while structural break is present in the series for N-11 countries[3]. We find that that globalization and CO_2 emissions are integrated at I(1). Thus, we apply the bounds-testing approach to test for the presence of cointegration between globalization and CO_2 emissions for the case of N-11 countries for the period 1972–2015.

[3] These structural breaks are outcome of environmental and trade policies implemented in N-11 countries over sample period of time.

Table-2: Unit Root Analysis

Country	Variable	ADF at level		ADF at 1st difference	
		T-statistic	Break Year	T-statistic	Break Year
Bangladesh	$\ln C_t$	-7.6450*	2005	-10.0923*	1998
	$\ln G_t$	-3.4425	1995	-10.0715*	1989
Egypt	$\ln C_t$	-4.4615	1987	-8.8896*	1993
	$\ln G_t$	-4.8940	2007	-5.2195**	1990
Indonesia	$\ln C_t$	-3.7384	1997	-7.1881*	1998
	$\ln G_t$	-4.9810	1990	-6.9838*	1998
Iran	$\ln C_t$	-3.117	1988	-5.9334*	1999
	$\ln G_t$	-5.221**	1998	7.8066*	2004
Mexico	$\ln C_t$	-2.8427	2006	-9.0781*	1989
	$\ln G_t$	-4.9766	1991	-8.2679*	1992
Nigeria	$\ln C_t$	-4.6743	1999	-7.9615*	2000
	$\ln G_t$	-3.5845	2008	-6.7071*	1986
Pakistan	$\ln C_t$	-2.7495	1992	-9.1864*	2007
	$\ln G_t$	-3.4291	1988	-8.7005*	1989
Philippines	$\ln C_t$	-3.2580	1988	-7.5641*	1986
	$\ln G_t$	-4.2665	2003	-8.4530*	1996
Turkey	$\ln C_t$	-3.6512	2000	-6.4998*	1987
	$\ln G_t$	-3.9048	1991	-8.6033*	1990
South Korea	$\ln C_t$	-4.2766	1997	-7.5747*	2000
	$\ln G_t$	-3.4554	1987	-6.3054*	1987
Vietnam	$\ln C_t$	-4.2383	1987	-11.0008*	1989
	$\ln G_t$	-2.5925	1994	-8.0969*	1988

Note: * shows significance at 1% and 5% levels, respectively.

The results of bounds-testing analysis are shown in Table-3. The computed ARDL-F statistic is more than the upper critical bound in the case of Bangladesh (5%), Egypt (10%), Indonesia (5%), Iran (1%), Nigeria (5%), Turkey (5%), South Korea (5%), and Vietnam (5%), where we treated globalization as the independent variable. This leads us to reject the null hypothesis of no cointegration between the variables. Thus, globalization and CO_2 emissions are cointegrated in their long-run association. In the case of Mexico and the Philippines, we may accept the null hypothesis because the upper critical bound exceeds the computed ARDL-F statistic[4]. This confirms the presence of a neutral association between globalization and CO_2 emissions in these two countries. Therefore, globalization and CO_2 emissions have a cointegration relationship in 9 of 11 countries (82% of the sample) for the period 1972–2015 in the presence of structural breaks in the series.

Table-3: ARDL Bounds Testing Analysis[5]

Countries	Bangladesh	Egypt	Indonesia	Iran	Mexico	Nigeria	Pakistan	Philippines	Turkey	South Korea	Vietnam
Lag Length	2, 2	2, 2	2, 2	2, 2	2, 2	2, 2	2, 2	2, 2	2, 2	2, 2	2, 2
Break Year	2005	1987	1997	1988	2006	1999	1992	1988	2000	1997	1987
F-Statistics	8.671**	6.859*	7.602**	9.686*	6.144**	6.895**	6.988**	0.263	6.715**	8.292**	8.105**
R^2	0.8131	0.8382	0.8100	0.5665	0.5644	0.6162	0.3210	0.2727	0.8003	0.7870	0.5002
Adj-R^2	0.6051	0.6009	0.6066	0.4840	0.3161	0.4020	0.1318	0.1419	0.6491	0.5760	0.4008
D.W Test	1.7030	2.1901	2.1502	1.9492	1.7077	1.8824	1.6768	1.8009	1.9021	1.9701	1.7698
Diagnostic Tests											
$\chi^2 NORMAL$	0.3180	3.2703	1.7303	0.8052	0.2732	0.3201	0.6272	0.3080	2.1717	0.1221	3.1021
$\chi^2 SERIAL$	1.1916	1.3023	0.3431	2.0522	0.1522	0.1220	1.2622	1.4282	1.5151	0.2004	0.6060
$\chi^2 ARCH$	0.1191	1.3000	0.2530	0.6262	2.2422	0.3462	1.2023	0.0328	0.1043	0.2402	0.1704
$\chi^2 WHITE$	1.0907	0.5311	0.3039	1.1232	1.3236	0.3081	0.3227	2.6005	0.1140	0.2504	2.0201
$\chi^2 REMSAY$	1.0316	1.4160	0.3505	2.3032	0.8320	0.9012	0.6061	0.5007	0.2118	1.7212	2.3730
CUSUM	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable
CUSUMsq	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable

Note: We use the ARDL empirical model with unrestricted intercept and unrestricted trend. The upper and lower critical bounds developed by Narayan (2005) are 8.803, 7.317 (6.373, 5.360) and 5.377, 4.437 at the 1% (5%) and 10% levels, respectively. The asterisks * and ** show significance at the 1% and 5% levels, respectively.

Table-4 addresses the long-run and short-run impact of globalization on CO_2 emissions. In the long run, we note that globalization impedes environmental quality by increasing CO_2 emissions statistically at the 1%, 5%, and 10% significance levels. Keeping all else constant, a 1% increase in globalization leads to an increase in CO_2 emissions by 1.7140% (Bangladesh), 1.8404% (Egypt), 1.6310% (Indonesia), 1.3040% (Iran), 0.4182% (Mexico), 1.3116% (Pakistan),

[4] The lagl length election is based on Akaike Information Criterion (AIC).

[5] We have compared our computed ARDL F-statistic with the critical bounds provided by Narayan (2005). If the upper critical bound is lower than the computed ARDL F-statistic, it shows the presence of cointegration. The hypothesis of no cointegration should be accepted if the lower critical bound is more than the computed ARDL F-statistic.

0.2879% (The Philippines), 1.2298% (Turkey), 1.9071% (South Korea), and 1.7333% (Vietnam). This empirical evidence is consistent with the findings of Shahbaz et al. (2015), who report that globalization is dangerous for environmental quality in India. In the case of Pakistan, Nasir and Rehman (2010) use trade openness as indicator of globalization, and report that trade openness impedes environmental quality by increasing carbon emissions. In the case of Nigeria, globalization is negatively and significantly associated with CO_2 emissions. This implies that there is a decrease of 0.6763% in CO_2 emissions with a 1% increase in globalization. This empirical finding is consistent with Shahbaz et al. (2013) for the Turkish economy, who noted that globalization lowers carbon emissions and improves environmental quality. In the short run, globalization increases CO_2 emissions significantly in the case of Bangladesh, Iran, and South Korea. The impact of globalization on CO_2 emissions is positive and statistically insignificant in Egypt and Indonesia. In the case of Nigeria, Turkey, and Vietnam, the relationship between globalization and CO_2 emissions is negative, but statistically insignificant.

Next, we compare the short-run elasticity with the long-run elasticity of globalization, following Narayan and Narayan (2010)[6]. Globalization leads to less CO_2 emissions over time if the short-run globalization elasticity is greater than the long-run elasticity, which confirms the presence of an EKC (i.e. inverted-U shaped pattern) relationship between the two variables. If the long-run globalization elasticity is more than the short-run elasticity, globalization increases carbon emissions over time, which represents the U-shaped relationship between globalization and

[6] Economic growth increases carbon emissions over time if the long-run elasticity is greater than the short-run elasticity of economic growth, which indicates a U-shaped relationship between both variables. If the short-run elasticity is more than the long-run elasticity of economic growth, then economic growth leads to a decrease in CO_2 emissions over time, which presents the EKC (i.e., inverted-U shaped pattern) relationship between economic growth and carbon emissions.

carbon emissions. Our empirical evidence indicates that the short-run elasticity of globalization is greater than the long-run elasticity for Bangladesh, Iran, and South Korea. This shows that globalization has increased CO_2 emissions over the long run, confirming the presence of a U-shaped relationship between globalization and carbon emissions for these three countries. Thus, globalization initially accompanies less carbon emissions, but after reaching a certain level, CO_2 emissions begin to rise. This may be due to obsolete technology being used to enhance domestic production in developing countries (i.e. N-11 countries).

Table-4: Long run and Short run Analysis

Countries	Long run		Short run		
	G_t	$D_{BreakYear}$	ΔG_t	$D_{BreakYear}$	ECM_{t-1}
Bangladesh	1.7140 *** (3.7950)	0.1181* (3.4845)	0.5151** (2.1743)	0.8176* (3.6756)	-0.3001*** (-3.1020)
Egypt	1.8404*** (6.4555)	0.2255** (2.6814)	0.0744 (0.2021)	-0.0368** (-2.3404)	-0.1601** (-2.5010)
Indonesia	1.6310*** (18.0420)	-0.1721 (-1.5368)	0.1879 (0.8939)	-0.0207*** (-1.8904)	-0.1639** (-2.6020)
Iran	1.3040*** (15.2551)	0.3532* (7.6326)	0.8007*** (3.7380)	0.0604 (1.653)	-0.1003*** (-3.3767)
Mexico	0.4182* (3.5631)	0.0265 (0.5879)	-0.1182 (-0.3080)	-0.0153 (-1.2486)	-0.1618 (-1.2538)
Nigeria	-0.6763*** (-3.1608)	-0.0399** (-2.3202)	-0.5091 (-0.7788)	-0.0072 (-1.4175)	-0.2502** (-2.4008)
Pakistan	1.3116*** (17.1049)	0.0557 (1.2157)	0.1314 (0.1805)	-0.0087 (-1.4387)	-0.1200 (-0.5338)
Philippines	0.2879*** (3.2696)	0.0477 (1.6060)	-0.1817 (-0.2031)	0.0324 (1.5859)	-0.1801 (-1.1021)
Turkey	1.2298*** (23.1202)	0.0783*** (1.7230)	-0.2191 (-0.8405)	0.0075 (0.1119)	-0.1701* (-1.8021)
South Korea	1.9071*** (3.3171)	-0.1892* (-3.1864)	0.7070** (2.2381)	-0.0473* (-2.6183)	-0.1190** (2.4331)
Vietnam	1.7333*** (14.7050)	-0.5533* (-4.8625)	-0.8009 (1.1981)	0.0570 (1.3339)	-0.2030*** (-3.6513)

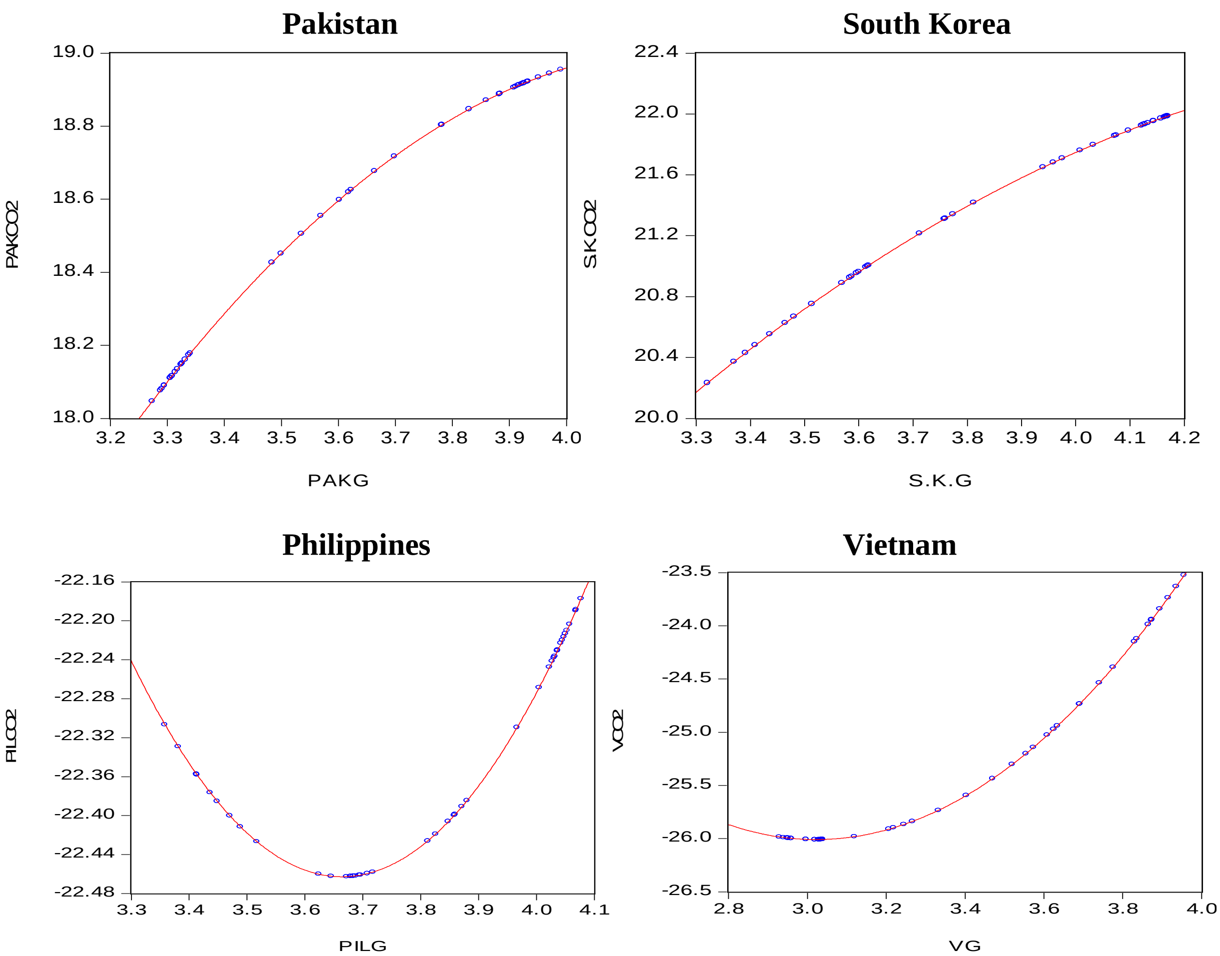
Note: ***, ** and * show significance at the 1%, 5% and 10% levels, respectively.

Brown and McDonough (2016) advocate that comparing the short run and long-run elasticity is not a conclusive way to show the presence of the EKC shape between globalization and carbon emissions. They further argue that the EKC is found in the upward-sloping range if the long-run elasticity is greater than the short-run elasticity of globalization with respect to carbon emissions. Similarly, if the short-run elasticity is more than long-run elasticity of globalization with respect to CO_2 emissions, then the EKC is found in the downward-sloping range. The EKC is found to be at a maximum if the short-run and long-run elasticities are alike. The time derivative of globalization with respect to carbon emissions simply shows how the association between globalization and carbon emissions changes over time but is unable to provide any information about whether the EKC is present. Note that the existence of the EKC association between globalization and CO_2 emissions is a long-run phenomenon. In such circumstances, one can argue that the comparison between the short-run and long-run elasticities provides information about the EKC-shaped association between globalization and carbon emissions, particularly if the short-run elasticity is different to the long-run elasticity. This further indicates that the application of the error correction model (ECM) to investigate the presence of the EKC is invalid, because the method provides information on the speed of the adjustment from the short run to the long run equilibrium path, but is unable to tell us anything about the turning point, which shows the decoupling between globalization and carbon emissions. The turning point indicates that after a certain level of globalization, globalization either raises or lowers CO_2 emissions. This shows the importance of the quadratic function of carbon emissions and that the EKC association between globalization and carbon emissions is a long-run phenomenon. Therefore, it only applies to the long-run equation of the carbon emissions function.

Following Itkonen (2012) and, later, Brown and McDononugh (2016), we employ the quadratic carbon emissions function to examine whether the association between globalization and carbon emissions has an inverted-U or U shape. To do so, we include the squared term of globalization (G_t^2) in the carbon emissions function (see Table-5).[7] The results show an inverted-U shaped association between globalization and carbon emissions (i.e., the EKC hypothesis) for Pakistan and South Korea. Here, a 1% increase in globalization raises CO_2 emissions by 8.9970% (9.2995%), while the negative sign of the squared term corroborates the delinking of CO_2 emissions and globalization at the higher level of economic development in Pakistan (South Korea). This implies that globalization is initially aligned with CO_2 emissions, but improves environmental quality at later stages of economic development. The existence of the EKC pattern between globalization and carbon emissions suggests that globalization is environment friendly. This suggests that more attention is needed to clean environment by reducing carbon emissions and using globalization as an economic tool to enhance economic development over the long term in Pakistan and South Korea (see Figure-1). This empirical evidence is similar to that provided by Shahbaz et al. (2015, 2017a), who validate the presence of the EKC hypothesis between globalization and carbon emissions. In contrast, the association between globalization and CO_2 emissions is U-shaped for the Philippines and Vietnam, indicating that globalization initially lowers CO_2 emissions, but then degrades environmental quality at later stages of economic development. Here, the harm to environment may be due to the implementation of poor environmental laws and regulations.

[7]The results of a diagnostic analysis are reported in Table-5. We find the normal distribution in the residual terms of all models. This empirical evidence reveals the absence of serial correlation. There is no evidence of ARCH and white heteroskedasticity. The Ramsay-Reset test statistic validates the good specification of the empirical equations.

Figure-1: Inverted-U and U Shape Curves



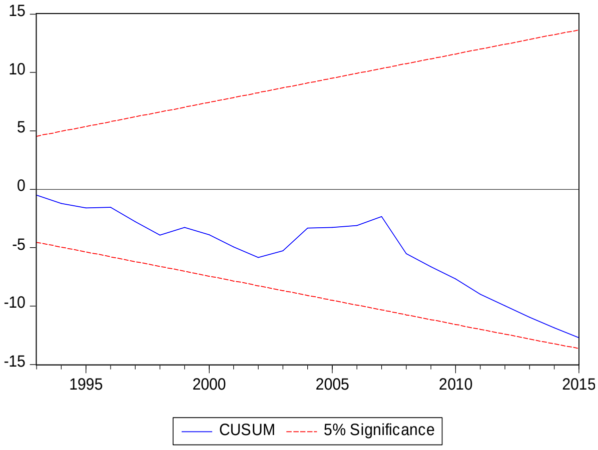
The stability of OLS estimates is validated by applying the CUSUM and CUSUMSQ tests (see Figure-2). Note that in the case of Pakistan, the CUSUM and CUSUMSQ remain within the critical bounds, which confirms the stability and reliability of the empirical estimates. In the case of South Korea, the diagram of the CUSUM test remains within critical bounds, but the diagram of the CUSUMSQ test exceeds the upper critical bound for 1998, which reflects the financial crisis of 1997. The financial crisis not only affected economic activity, but also the environmental and globalization indicators. We conclude that, overall, the empirical estimates for South Korea are reliable and stable.

Table-5: EKC Analysis

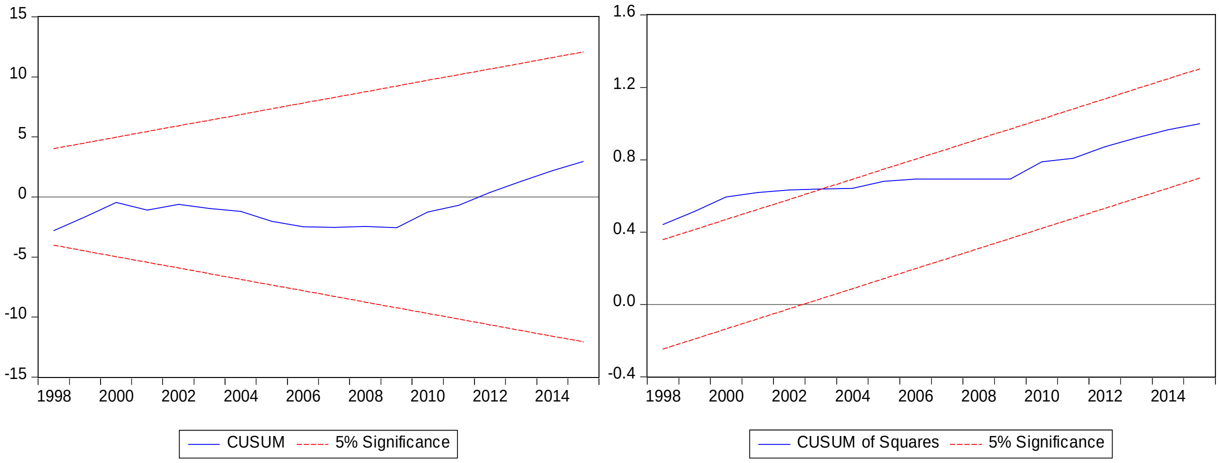
Dependent Variable: C_t											
Variable/Country	Bangladesh	Egypt	Indonesia	Iran	Mexico	Nigeria	Pakistan	Philippines	Turkey	S. Korea	Vietnam
Constant	-6.4697	-17.6301	-10.2166	-2.0588	-74.7730*	24.4610	-19.0373*	22.0997*	4.3908	-19.5876*	26.4611*
G_t	1.4080*	6.6097	3.2729	0.8007	38.0059	-12.3636	9.0007**	-12.2063*	-3.1210	9.3090*	-17.2021*
G_t^2	0.0345	-0.5705	-0.3124	0.1709	-4.8090*	1.6004	-1.1603**	1.6030*	05410**	-0.9707*	2.8075*
$D_{Break\ Yea}$	0.1108*	0.2189**	-0.2226	0.3506*	0.1439**	0.0155	-0.0241	0.0386	0.0454	-0.0734	-0.0284*
R^2	0.9714	0.8755	0.8889	0.8693	0.4771	0.2728	0.8873	0.4222	0.9321	0.9730	0.9584
F-statistic	69.760*	14.4209*	16.4100	11.3100*	18.7102*	7.6927*	16.1546*	14.9824*	28.1697	74.0897*	47.2762*
D. W Test	1.6773	1.5757	1.4489	1.4297	2.3781	1.5509	2.1993	2.3039	1.5861	1.7632	1.7941
Diagnostic Tests											
$\chi^2 NORMAL$	1.2892	1.2982	1.9282	2.2892	3.0002	2.2298	2.1112	2.3232	2.8289	2.2989	2.8896
$\chi^2 SERIAL$	2.9081	2.9810	2.1980	1.2918	1.8019	2.1080	2.1281	2.3930	2.9789	2.7970	2.8976
$\chi^2 ARCH$	2.1135	2.1335	2.1531	1.2531	2.5130	2.1636	2.5535	2.4545	2.6561	2.8534	2.5456
$\chi^2 WHITE$	1.9082	1.9802	1.8290	2.2890	2.2892	1.2898	1.6296	1.5494	1.4296	1.2494	1.8929
$\chi^2 REMSAY$	2.1876	2.8716	2.7618	1.9919	1.6781	2.6717	2.6166	2.5658	2.6413	2.6414	2.6808
Note: * and ** show significance at the 1% and 5% levels, respectively.											

Figure-2: CUSUM and CUSUMsq

Pakistan



South Korea



The direction of causality between globalization and CO_2 emissions is found by applying the innovative accounting approach (IAA) rather than the VECM Granger causality method. The VECM Granger causality is suitable for detecting a causal relationship between variables within the sampled period. However, to determine causality ahead of the sample period, the innovative accounting approach is much better. This approach is a combination of a variance decomposition analysis (VDA) and the impulse response function (IRF). The VDA shows the degree of predicted error variance for a variable, described by innovations stemming from the independent variable over various time horizons ahead of the selected time span. Pesaran and Shin (1999) indicated that the proportional contribution of one variable following innovative shocks occurring in other variables can be investigated using the generalized forecast error variance decomposition method. This method is not sensitive to the ordering of variables determined by the VAR system, and can be used to investigate simultaneous shock effects. It was argued by Engle and Granger (1987), and later by Ibrahim (2005), that using the VAR framework, the variance decomposition approach provides comparatively efficient empirical results. The results of the variance decomposition approach are reported in Table-6. Note that an innovative shock stemming from globalization explains CO_2 emissions by 21.51%, 66.27%, 45.77%, 30.84%, and 56.44% in Bangladesh, Egypt, Indonesia, Turkey, and Vietnam, respectively. In Iran, Mexico, Nigeria, Pakistan, Philippines, and South Korea, globalization through the innovative shock explains CO_2 emissions minimally (i.e., by 0.48%, 11.34%, 1.59%, 0.84%, 3.16%, and 4.85%, respectively). In contrast, innovative shocks arising from CO_2 emissions explain globalization by 37.80%, 82.04%, 24.30%, 25.85%, 27.75%, 68.80%, and 42.37% in Bangladesh, Iran, Nigeria, South Korea, and Vietnam, respectively.

These empirical findings indicate that bidirectional causality exists between globalization and CO_2 emissions in Bangladesh and Vietnam. Thus, globalization and CO_2 emissions are complementary. This reveals that globalization causes environmental quality to deteriorate by increasing CO_2 emissions, and as a result, CO_2 emissions cause globalization via economic growth. Therefore, globalization causes CO_2 emissions in Egypt, Indonesia, and Turkey. This finding is consistent with that of Shahbaz et al. (2015, 2017a), who report unidirectional causality from globalization (economic, social, and political) to carbon emissions for India and

China. Globalization is Granger-caused by CO_2 emissions in Iran, Nigeria, Pakistan, the Philippines, and South Korea. A neutral effect exists between globalization and carbon emissions in Mexico.

The impulse response function (see Figures 3 and 4) is an alternative to the variance decomposition method, which shows how long, and to what extent the dependent variable reacts to shocks stemming from the independent variables. Note that the response of CO_2 emissions is positive owing to the forecast error stemming from globalization. This implies that globalization contributes to the degradation of environmental quality by increasing carbon emissions in Bangladesh, Egypt, Indonesia, Turkey, and Vietnam. For the remaining countries, such as Iran, Mexico, Nigeria, Pakistan, the Philippines, and South Korea, the response to CO_2 emissions is mixed owing to forecast errors in globalization, but is statistically insignificant. Globalization responds positively owing to forecast errors occurring in CO_2 emissions for Bangladesh, Indonesia, Iran, Mexico, Pakistan, the Philippines, Turkey, and South Korea. The response of globalization is negative owing to forecast errors stemming from carbon emissions for Nigeria and Vietnam.

Table-6: Variance Decomposition Approach

Time Horizon	Variance Decomposition of $\ln C_t$										
	Bangladesh	Egypt	Indonesia	Iran	Mexico	Nigeria	Pakistan	Philippines	Turkey	S. Korea	Vietnam
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.2113	1.4361	0.0348	0.5358	1.7318	0.1615	0.0405	0.9047	4.9522	0.6629	5.3280
3	1.3739	5.0904	1.6694	0.6999	2.3083	0.1539	0.0301	1.1406	8.5676	1.3580	9.6483
4	2.8818	10.7830	5.6045	0.7182	3.1410	0.1452	0.0373	1.0906	11.5340	1.9840	16.2948
5	5.1444	17.7529	10.8297	0.6954	3.9679	0.1888	0.0664	0.9785	14.1111	2.5149	23.8560
6	7.4521	25.2345	16.3530	0.6631	4.8285	0.2868	0.1130	0.9147	16.4351	2.9594	31.6300
7	9.7364	32.5636	21.6031	0.6311	5.6951	0.4242	0.1737	0.9407	18.5672	3.3313	38.7348
8	11.8468	39.3181	26.3312	0.6022	6.5526	0.5840	0.2448	1.0604	20.5378	3.6434	44.6168
9	13.7611	45.2929	30.4727	0.5771	7.3855	0.7523	0.3233	1.2601	22.3642	3.9065	49.0909
10	15.4694	50.4407	34.0530	0.5555	8.1810	0.9193	0.4067	1.5203	24.0579	4.1296	52.2512
11	16.9857	54.8059	37.1331	0.5370	8.9292	1.0787	0.4930	1.8219	25.6288	4.3199	54.3283

12	18.3283	58.4753	39.7828	0.5212	9.6231	1.2269	0.5806	2.1485	27.0852	4.4830	55.5803
13	19.5182	61.5485	42.0682	0.5077	10.2585	1.3623	0.6682	2.4876	28.4354	4.6237	56.2364
14	20.5751	64.1215	44.0480	0.4962	10.8336	1.4844	0.7549	2.8298	29.6871	4.7458	56.4788
15	21.5169	66.2798	45.7715	0.4862	11.3488	1.5935	0.8400	3.1686	30.8477	4.8523	56.4428
	Variance Decomposition of $\ln G_t$										
1	7.3830	7.7674	1.2178	2.4539	1.7547	1.7361	1.3172	0.1246	3.7552	5.8770	7.2220
2	7.4897	9.3400	5.0619	10.6122	1.0555	1.3756	3.2224	0.2234	1.9799	13.1549	16.0268
3	10.8750	9.4482	7.6401	23.6711	0.9725	2.8107	2.5464	0.1973	1.7515	20.6754	19.8711
4	13.9251	9.4813	9.4543	36.9981	1.3163	5.2631	2.1509	0.8737	2.2361	28.4753	23.4973
5	17.2340	9.4428	10.8565	48.1461	1.9068	8.1030	2.2479	2.5374	3.1224	35.9370	26.5495
6	20.3017	9.3872	11.9984	56.7452	2.6670	10.9099	2.9078	5.0186	4.2504	42.5938	29.1985
7	23.1631	9.3239	12.9510	63.2068	3.5283	13.4751	4.1433	7.9811	5.5171	48.2490	31.5020
8	25.7522	9.2599	13.7557	68.0577	4.4417	15.7239	5.9115	11.1105	6.8508	52.9169	33.5145
9	28.0860	9.1978	14.4416	71.7363	5.3702	17.6518	8.1392	14.1837	8.2014	56.7191	35.2804
10	30.1766	9.1390	15.0301	74.5665	6.2865	19.2853	10.7330	17.0706	9.5346	59.8086	36.8363
11	32.0486	9.0841	15.5385	76.7780	7.1714	20.6616	13.5917	19.7104	10.8274	62.3298	38.2128
12	33.7256	9.0332	15.9801	78.5324	8.0113	21.8190	16.6161	22.0858	12.0655	64.4040	39.4353
13	35.2311	8.9864	16.3660	79.9439	8.79781	22.7925	19.7161	24.2045	13.2405	66.1276	40.5250
14	36.5862	8.9434	16.7050	81.0941	9.52581	23.6124	22.8154	26.0860	14.3483	67.5749	41.4998
15	37.8099	8.9040	17.0043	82.0422	10.19312	24.3046	25.8529	27.7549	15.3883	68.8030	42.3745

Figure-3: Impulse Response Function (Response of $\ln C_t$ to $\ln G_t$)

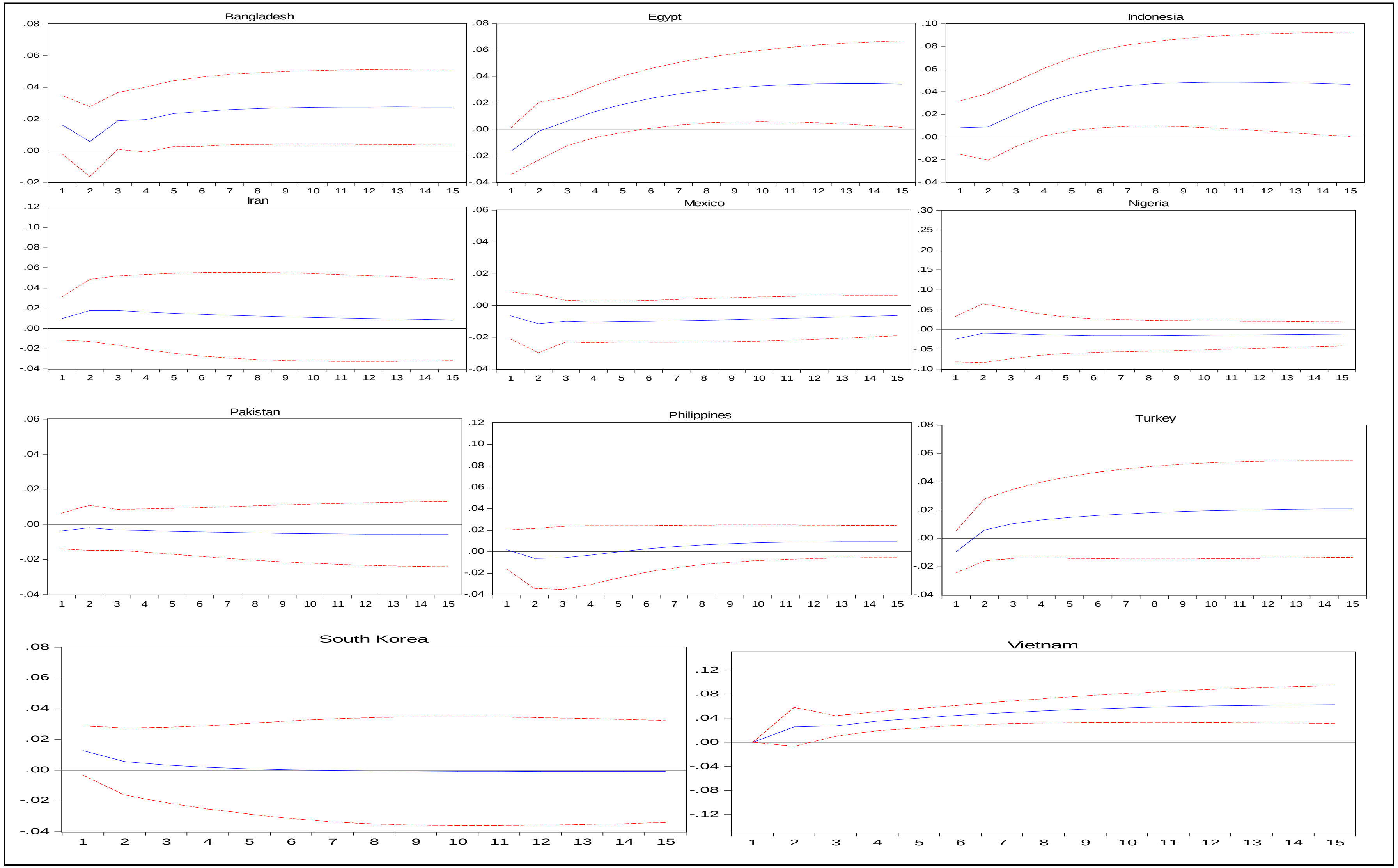
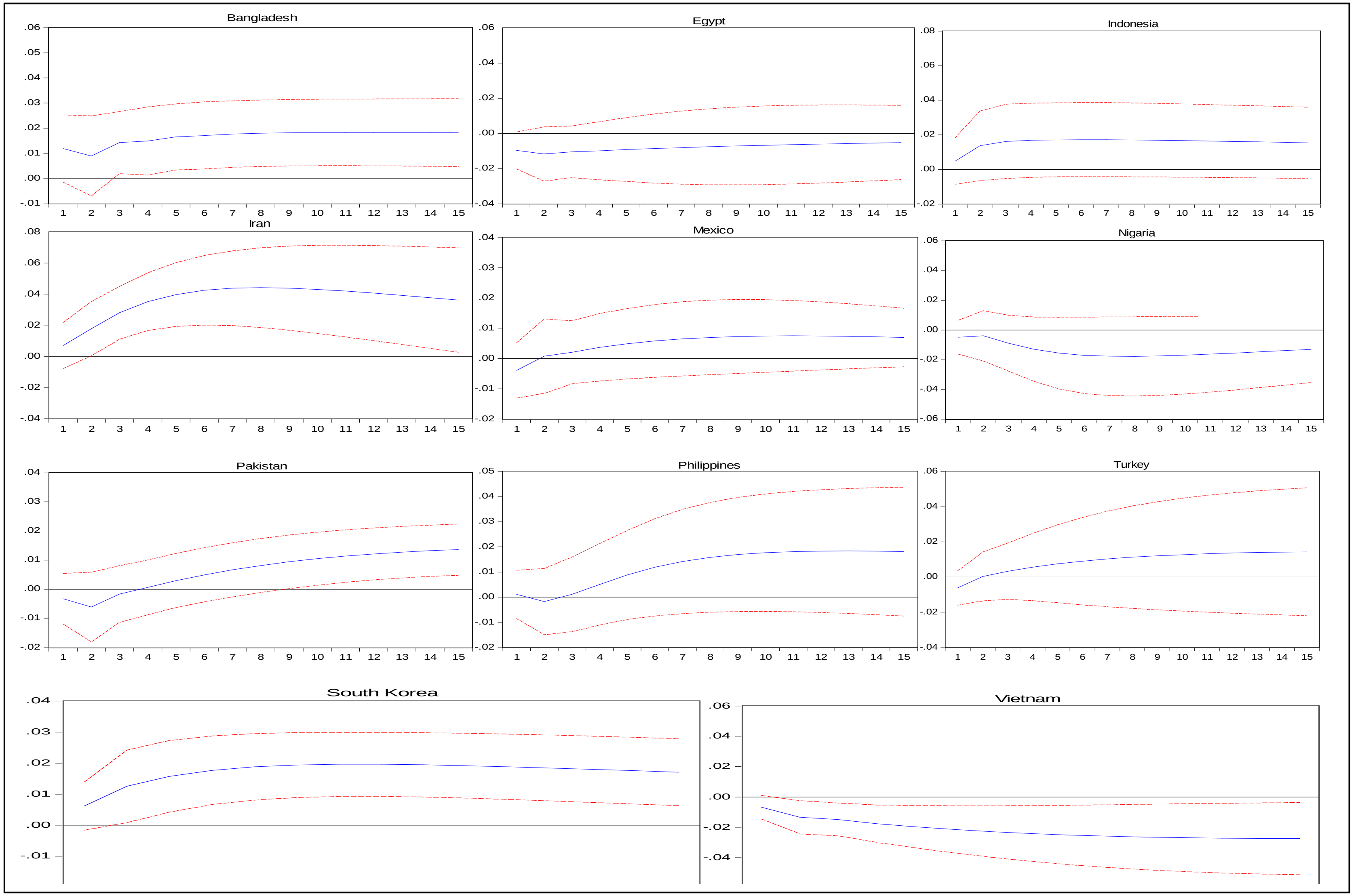


Figure-4: Impulse Response Function (Response of $\ln G_t$ to $\ln C_t$)



5. Conclusion and Policy Implications

The empirical investigation of the globalization–emissions nexus is a newly debated area for researchers, and has not been well researched. Much energy policy literature is available on the relationship between economic growth and CO_2 emissions, and is termed the environmental Kuznets curve (EKC) hypothesis, yet few studies are available that investigate the association between globalization and carbon emissions, yielding inconclusive empirical findings. However, to the best of our knowledge, none of the studies have examined whether the association between globalization and carbon emissions is an inverted-U shaped for N-11countries, except for Shahbaz et al. (2015a, 2017a) in the case of India and China. This study provides an empirical investigation of the EKC hypothesis for N-11 countries using time series data for the period 1972–2015. The EKC hypothesis is validated by comparing the short-run and long-run globalization elasticities. For instance, if the short-run globalization elasticity is more than the long-run globalization elasticity, then this is evidence that globalization lowers CO_2 emissions over the long run and the EKC hypothesis is valid (i.e., an inverted-U-shaped relationship). In contrast, the association between globalization and carbon emissions is U-shaped if the long-run globalization elasticity is more than the short-run globalization-elasticity (i.e., globalization increases carbon emissions over the long run). Following Brown and McDonough (2016), the unit root and cointegration tests are applied, and the EKC hypothesis is re-investigated by employing a quadratic carbon emissions function, owing to the problems associated with comparison of the short-run and long-run globalization elasticities.

Based on comparison of the elasticities, we find that the long-run elasticity is more than the short-run elasticity of globalization (i.e., globalization tends to increase carbon emissions over the long run). This confirms the existence of a U-shaped association between globalization and carbon emissions in the case of Bangladesh, Iran, and South Korea. Using a quadratic carbon emissions function, we find the presence of the EKC hypothesis (i.e., inverted U-shape) between globalization and CO_2 emissions in Pakistan and South Korea, but in the case of the Philippines and Vietnam, the relationship between the two variables is U-shaped.

The empirical evidence based on short-run and long-run elasticities shows that globalization leads to an increase in carbon emissions in Bangladesh, Iran, South Korea, the Philippines, and Vietnam. The results show that the short-run elasticity is less than the long run elasticity of globalization, which indicates that the relationship is U-shaped. This suggests that these countries should direct their policies on globalization toward a sustainable environment in order to maintain the living standards of their population. In doing so, energy-efficient technology should be encouraged in order to stimulate domestic production. To reap the benefits of globalization, these economies should explore and use renewable energy sources, such as sunlight, wind, rain, tides, and geothermal heat, for sustainable long-run economic development and to mitigate environmental degradation. Foreign investors should be directed to invest in the energy sector for innovations in energy. In doing so, the government(s) must introduce investment incentives such as tax holidays or subsidies for investing in the energy sector. Energy research funds should be used for research & development in the energy sector to encourage innovations in energy-efficient technology. Energy-efficient technology can be used to enhance domestic production and the volume of exports to international market. Increased exports will lead to greater foreign earnings, which can be used to import more advanced and environment friendly technology from advanced countries.

An inverted-U-shaped relationship (i.e., the EKC) exists between globalization and carbon emissions in the case of Pakistan, which suggests that government investment in renewable energy sources should be prioritized in future energy policies to maintain energy supply. Pakistan has been facing shortages for the past three decades, and a long-run renewable energy policy needs time, not only to enhance domestic production, but also to improve environmental quality for sustainable living standards and economic development. Thus, Pakistan needs to focus on hydro energy, a source considered to be capital-intensive. Hydro energy is the cheapest way to produce electricity and maintain future demand due to long term and sustainable economic development. There is also a need to direct economic and non-economic drivers of carbon emissions through tax, trade, and environmental policies. For South Korea, an inverted U-shaped relationship between globalization and carbon emissions implies that globalization harms environmental quality in the initial stage of economic integration, but improves it beyond the threshold level of emissions. This further shows that globalization is not beneficial in the short run, but is effective in long run in terms of improving environmental quality. Policymakers should pursue policies of sustainable environmental quality by adding globalization as a key economic determinant in carbon emissions function.

For future research on the globalization–emissions nexus, related studies should focus on sectoral levels (i.e., agriculture, transport, commerce, industry, and household factors) to determine CO_2 emissions in N-11 countries. For rigorous empirical evidence, industrial and micro-level analyses are necessary to develop comprehensive economic and environmental policies to maintain long-term economic development. Lastly, globalization emissions should be tested at regional levels using global panel data in high-, middle-, and low-income countries. We can further disaggregate these countries' panel data into OECD, non-OECD, East Asia & Pacific, Europe & Central Asia, Latin America & Caribbean, Middle East & North Africa, North America, South Asia, and Sub-Saharan Africa to examine the impact of globalization on carbon emissions by considering other economic and non-economic factors affecting environmental quality. Globalization dimensions such as economic, social, and political globalization affect environmental degradation differently. In this regard, empirical analyses of each dimension would be helpful to policymakers when designing comprehensive environmental policy by considering how each dimension affects environmental quality.

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