Factors influencing CO2 Emission in China: A Nonlinear Autoregressive Distributed Lags Investigation

AhAtil, Ahmed and Bouheni, Faten Ben and Lahiani, Amine and Shahbaz, Muhammad

ESC Rennes Business School, France, ISC Paris Business School, France, LEO-University of Orléans, France, Montpellier Business School, France

1 January 2019

Factors influencing CO_2 Emission in China: A Nonlinear Autoregressive Distributed Lags Investigation

Ahmed Atil
ESC Rennes Business School, France

Faten Ben Bouheni
ISC Paris Business School, France
Email: fbenbouheni@sdsu.edu

Amine Lahiani
LEO-University of Orléans,
Montpellier Business School, France
Email: amine.lahiani@univ-orleans.fr

Muhammad Shahbaz
Montpellier Business School, France
Email: muhdshahbaz77@gmail.com

Abstract

This paper investigates the environmental impact of economic growth, energy consumption, financial development and globalization in China over the period 1970Q1-2015Q4. In particular we consider four dimensions of globalization namely economic, social, political and overall globalization. The Nonlinear Autoregressive Distributed Lags (NARDL) model has been employed to capture the potential asymmetric impact of the determinants of dioxide carbon emissions in China. Interestingly, findings show that: (1) In the short-run: economic growth and financial development have a significant symmetric impact on CO_2 emissions. Energy consumption has a nonlinear and asymmetric influence on CO_2 emissions. However, economic globalization does not impact CO_2 emissions. (2) In the long-run: economic growth, financial development and economic globalization exhibit an asymmetric influence on carbon emissions in model including the economic dimension of globalization. Economic growth has a positive symmetric impact on CO_2 emissions in model including social globalization, however, it does not influence CO_2 emissions in case of political or overall globalization. In addition, energy consumption is positively linked to CO_2 emissions. Moreover, financial development does not influence carbon emission in models including respectively social, political and overall globalization. Social and overall globalization have a significant influence on CO_2 emissions. The results of this paper are important for policies that would promote sustainable development and environment protection.
Keywords: Energy, Growth, Financial Development, Globalization, CO_2 Emissions

1. Introduction

One of the most severe problems of the modern world is the climate change and its important negative consequences on environment. The human activity, particularly carbon dioxide emissions, has been considered among the main factors contributing to the changing of climate in the last decades (IPCC, 2007). It is thus crucial to determine factors that foster carbon dioxide emissions. In fact, heavy emission of carbon dioxide is nowadays harmful for environment with a high level of air pollution. Environmental policymakers should give a closer look at the latter issue because of the greenhouse effect and global warming. Renewable energy resources constantly renew themselves and have less negative effect on environment than fossil energy technologies, for instance. Renewable energy resources are largely preferred to their nonrenewable counterparts because they allow reducing carbon dioxide emissions (Dogan and Seker, 2016). Consequently, they enable to protect the environment. Recall that renewable energy is considered as a viable option to enhance access to energy and mitigate climate change (Moomaw et al. 2011). Kim and Park (2016) examine the relationship between financial development and renewable energy deployment and show that financial development is favorable for renewable sectors basically for renewable sectors characterized by high dependence on external finance. They conclude that financial development leads to a reduction in CO_2 emissions.

This paper highlights the factors impacting the CO_2 emissions in China. According to Lin et al. (2016), China's impressive economic performance in the past decades has resulted in increased carbon intensity. Over the past few years, China's economy has grown at an average of over 7%, exceeding that of the United States and the European Union combined. However, this impressive economic performance has led to an increase in carbon (CO_2) emissions. The United States Energy Information Administration mentioned that China's primary energy consumption increased from17.29 Quad BTU in 1980 to 103.72 Quad BTU in 2011. Similarly, her electricity net consumption increased from 261.49 billion kilowatthours in 1980 to 4207.70 billion kilowatthours in 2011, an increase of over 1500%. With the increase in total primary energy and coal-dominated electricity consumption, carbon emission also increased significantly. Carbon emission associated with electricity production and consumption in China is high because coal is the dominant fuel for electricity production in the country. As at 2012, China's energy consumption-related CO2 emission stands at 8547.74 million metric tons compared to 1448.46 million metric tons in1980, which makes it the largest CO2 emitter in the world (Lin et al., 2016). Consequently, analyzing the drivers of this prominent increase of CO_2 emissions in China is crucial. Indeed, we study the impact of the gross domestic product growth, energy consumption, financial development and globalization on carbon dioxide emission in China by using the Nonlinear Autoregressive Distributed Lags (NARDL) model.

This paper contributes to existing literature by four folds: First, we apply the multivariate nonlinear ARDL (NARDL) of Shin et al. (2014) to test for the possible nonlinear and asymmetric cointegration between carbon emissions and its determinants. The NARDL model is convenient for our setting as it jointly incorporates the long- and short-run asymmetric relationships among variables. Asymmetric and nonlinear linkages between economic variables could occur due to the complexity of economic systems and mechanisms leading to carbon emissions and its determinants. For instance, economic time series may be influenced by structural reforms, policy shifts, real and financial shocks, and regional and global imbalances. Contrary to economic and financial variables that depend on general macroeconomic instruments such as business cycle conditions, monetary policy adjustments and product market regulations, CO_2 emissions is rather more responsive to specific domestic and global energy market conditions.

Second, previous studies employed annual data and surprisingly none of them used higher frequency data such as quarterly or monthly. In this paper, we use quarterly data as the previous literature has pointed out the influence of data-frequency on empirical results (Narayan and Sharma, 2015).

Third, our study differs from previous studies by examining the effects of Gross Domestic Product (GDP), Energy Consumption (EC), Financial Development (FD) and Globalization (G) on carbon dioxide (CO_2) emissions in China from 1970Q1 to 2015Q4. Although there have been several studies on CO_2 emissions in the field of energy economics, majority of these studies focused on emerging countries[1]. In contrast, this paper analyses the determinants of CO_2 emissions in the largest emerging economy "China" and the largest CO2 emitter in the world. In addition, most of the empirical studies analyze the drivers of carbon emissions using panel data techniques, and do not adequately investigate countries individually. In contrast, we suspect that individual country characteristics such as GDP, energy consumption, financial development and globalization are important drivers of CO_2 emissions. The individual country characteristics and path ways are necessary given the significant differences in income level, financial development, energy consumption level and structure, technology advancement,

[1]See for instance, Tamazian et al. (2009), Jalil and Feridun (2011), Ozturk and Acaravi (2013)

energy market structure, mitigation and adaptation capabilities, development policy goals across countries, and globalization (Lin et al. 2016).

Finally, little attention was given to financial variables as a key determinant of CO_2 emissions. Previous studies explained CO_2 emissions mostly by the gross domestic product and energy variables such as renewable and non-renewable energy (Dogan and Seker, 2016) and energy consumption (Alam et al. 2011). Recent studies enlarged the set of potential determinants of CO_2 emissions considering new variables that account for financial development such as financial capital market, quality of firms governance and financial development as well as variables accounting for globalization such as trade openness and foreign direct investment (Talukdar and Meisner 2001, Classens and Feijen 2007). In this paper, in addition to the GDP variable and energy consumption, we investigate the impact of financial development and globalization on CO_2 emissions in China. Particularly, we consider four dimensions of globalization namely economic globalization (EG), social globalization (SG), political globalization (PG) and overall globalization (OG). Disentangling the individual effect of each type of globalization on CO_2 emissions in China is important because it will help authorities taking right decision in order to reduce CO_2 emissions domestically.

Therefore, our study empirically investigates the drivers of carbon dioxide emissions in the largest emerging economy "China". The results of this study have important implications for the implementation of future policies on financial policies in combination with macroeconomic policies in order to reduce CO_2 emissions. The importance of this paper lies with the fact that it takes into account the prominence of the effects of changes in economic growth, energy consumption, financial development and level of globalization on CO_2 emissions. In fact, the major findings are the following: (1) In the short-run, gross domestic product, energy consumption, financial development and globalization affect significantly CO_2 emissions; (2) In the long-run, energy consumption significantly deteriorates environment. However, in the short-run, more energy consumption increases CO_2 emissions while less energy consumption preserves environment; (3) In the long-run, economic globalization influences carbon dioxide emissions in asymmetric and nonlinear manners while social and overall globalizations reduce CO_2 emissions in a linear. Thus, higher level of economic globalization raises CO_2 emissions while lower level reduces CO_2 emissions. However, political globalization does not impact CO_2 emissions; (4) In the short-run, economic globalization does not impact CO_2 emissions. However, social, political and overall globalizations reduce CO_2 emissions and; (5) Financial development asymmetrically impacts dioxide carbon emissions only when it coupled with economic globalization. It does not exert any influence on dioxide carbon emissions if coupled with social, political or overall globalization.

The paper is structured as follows. Section-2 discusses literature dealing with the factors influencing carbon dioxide emissions. The following section introduces the methodology and data used while the next section discusses the empirical findings. Finally, the last section concludes and provides policy implications.

2. Literature review

2.1 Financial Development and CO_2 Emissions

Financial development may pass-through to energy consumption through two possible channels. A first stream of literature argues that financial development rises energy consumption because it fosters economic growth, which in turn, requires more demand for energy and may influence CO_2 emissions (Sadorsky 2010). Sadorsky (2011) decomposed the global effect of financial development on energy consumption into three different effects: direct effect through the purchase of energy-consuming goods, business effect through energy demand and wealth effect through an increase of energy demand resulting from higher economic confidence. This shows that all these channels affect environmental quality by influencing carbon emissions. A second stream of literature believes that financial development reduces energy consumption which in resulting, decline carbon emissions. Indeed, financial development leads to using less-energy consuming technologies which results in a fall of energy consumption and CO_2 emissions as well. The latter transmission channel is known as the technological effect (Tamazian et al. 2009, Shahbaz et al. 2013, Mahalik and Mallick 2014).

There has been substantial research attention on CO_2 emissions in recent years since, CO_2 emissions is considered as one of the major air pollutant and hence environment degradation (Astöm et al. 2013, Henneman et al. 2016). This is the main reason for which we focus on carbon emissions and its long- and short-run determinants. A number of studies have been conducted showing the relationship between gross domestic product and CO_2 emissions. Financial development is now-a-days considered as a key factor driving the level of CO_2 emissions. Various recent studies investigate the impact of financial development on CO_2 emissions. For instance, Katircioglu and Taspinar (2017) examined the moderating role of financial development in environmental quality by using comprehensive index of financial development along with economic growth and energy consumption for Turkish economy[2].

[2] They used domestic credit by banking sector as share of GDP, domestic credit to private sector as share of GDP, broad money supply as share of GDP, liquid liabilities as share of GDP and the ratio of commercial bank assets to total assets to generate financial development index by using Principal Component Analysis (PCA).

Their empirical analysis reveals that financial development reduces stimulates carbon emissions but energy consumption stimulates it. Furthermore, financial development stimulates economic growth which in resulting, adds in CO_2 emissions. In case of South Asia[3], Nasreen et al. (2017) noted that stable financial sector improves environmental quality by decreasing CO_2 emissions but energy consumption, economic growth and population density are major contributors of environmental degradation.

Abbasi and Riaz (2016) resort to the ARDL model to investigate the long-run relationship between CO_2 emissions and a set of economic and financial variables including financial development. They also employ an augmented version of the VAR model to capture the short-run linkage between carbon emissions and its determinants by splitting the sample period into two sub-samples in order to isolate the period 1988-2011 characterized by greater degree of liberalization and financial sector development. Their empirical results indicate that financial variables played a significant role in mitigating CO_2 emissions during the period 1988-2011 only. Additionally, the level of carbon dioxide emissions attributable to financial development is relatively small compared to the level of emission raising due to rising of per capita income. Economic growth increases energy consumption that, in turn, increases carbon dioxide emissions. The latter findings lead environmental deciders to adopt different mitigation policies able to attenuate the level of rising of carbon emission. Dogan and Seker (2016) employ the environmental Kuznets curve framework to study the influence of real output, renewable and non-renewable energy, trade and financial development on CO_2 emissions in a panel of 23 countries. They find that financial development and trade openness reduce carbon emission. For Portuguese economy, Shahbaz et al. (2016a) applied multivariate framework of carbon emissions function by financial development is major determinant of environmental degradation. Their results show that economic growth and energy intensity increase CO_2 emissions but financial development improves environmental quality by lowering CO_2emissions. Javed and Sharif (2016) investigated the determinants of carbon emissions using Pakistani data for the period of 1972-2103. They reported that energy consumption and financial development have positive and significant impact on CO_2 emissions but trade openness declines carbon emissions. In UAE, Charfeddine and Khediri (2016) applied regime-switching cointegration approach for the investigation of carbon emissions function. Their results indicate the presence of EKC association between financial development and CO_2 emission. They also noted that electricity consumption, trade openness and urbanization

[3] Pakistan, India, Bangladesh and Sri Lanka

improve environmental quality by lowering CO_2 emissions. Farhani and Ozturk (2016) applied bounds testing approach for examining the relationship between carbon emissions for Tunisian economy.

For Indian economic, Sehrawat et al. (2015) reinvestigated the association between financial development and carbon emissions by applying ARDL cointegration approach. They show that financial development degrades environmental quality by adding CO_2 emissions[4]. Salahuddin et al. (2015) employ panel data econometric methodology to investigate the relationship between economic growth, electricity consumption, financial development and CO_2 emissions. Their findings show absence of short-run relationship between the variables. In addition, electricity consumption and economic growth have a positive relationship with CO_2 emissions while the relationship between financial development and CO_2 emissions is found to be negative. Their results also indicate that economic growth and electricity consumption stimulate dioxide emission while financial development reduces it. Boutabba (2014) uses the autoregressive distributed lag model (ARDL) to detect the long-run impact of economic growth, financial development, energy consumption and trade openness on carbon emissions in India. The empirical findings show evidence of long-run causality running from financial development to CO_2 emissions. The long-run impact of financial development on CO_2 emissions is positive indicating that higher level of financial development contributes more to environment degradation. Energy consumption is also a major determinant of CO_2 emissions in the long-run in India. Using the bounds test within the ARDL framework, Shahbaz et al. (2013) show evidence of long-run influence of financial development on carbon emissions in Malaysia. Indeed, financial development is found to reduce CO_2 emissions in Malaysia preserving then the environment from being degraded. The previous approach is employed by Shahbaz et al. (2013a) to investigate the effects of financial development, economic growth, coal consumption and trade openness on CO_2 emissions in South Africa. Their results indicate that economic growth raises dioxide emissions while financial development and trade openness reduce it. Also, coal consumption contributes to deteriorate the environment by increasing CO_2 emissions. Shahbaz et al. (2013b) examine the linkages between economic growth, energy consumption, financial development, trade openness and CO_2 emissions in Indonesia over the period 1975Q1-2011Q4. Their results mitigate those of previous studies. They show that economic growth and energy consumption increase CO_2 emissions while financial development

[4] Their analysis also indicates that energy consumption, trade openness and urbanization are contributing factors to environmental degradation.

and trade openness reduces it. Similarly, Ozturk and Acaravci (2013) investigated carbon emissions function for Turkish economy. Their analysis indicated the insignificant effect of financial development on CO_2 emissions.

In case of China, Xiong and Qi (2017) applied the STIRPAT augmented model to analyze the relationship between financial development and carbon emissions using 30 provinces panel data for the period of 1997-2011. They noted that financial development improve environmental quality by reducing carbon emissions. Zhang (2011) investigates the impact of financial development on carbon emissions in China using a set of econometric techniques namely cointegration, Granger causality test and variance decomposition. Findings show that China's financial development acts as an important driver for increase of carbon emissions. Moreover, among the financial development indicators foreign direct investments influence the least carbon emissions in China. Jalil and Feridun (2011) reinvestigated the association between financial development and carbon emissions by adding energy consumption, trade openness and income as additional determinants in carbon emissions function. They noted that financial development declines CO_2 emissions but income, energy consumption and trade openness increase it. Once again, the results of these studies may be ambiguous due to use of different methods for different countries. Furthermore, the use linear econometric methodologies that impose similar size effect of positive and negative shocks of exogenous variables on the dependent variable. Ignorance of asymmetries occurred in time series data, may make previous empirical evidence meaningless. We found one study by Shahbaz et al. (2016b) filling this gap by using the recently developed nonlinear Autoregressive distributed lag model (NARDL) by considering Pakistani data. Their results show evidence of strong asymmetric among financial development, energy consumption, economic growth and CO_2 emission. They conclude that positive shocks of economic growth rise CO_2 emission revealing that economic growth and financial development contribute to the degradation of the environment in Pakistan.

2.3 Globalization and CO_2 Emissions

However, globalization is regarded as economic tool of improving economic growth and welfare by removing restrictions on trade and investment inflows. Given that globalization also affects CO2 emissions and economic activity via various channels. Having a country engaged in trade and investment activities, a higher amount of energy usage is required in production and consumption activities, which eventually releases more carbon dioxide to the environment. Globalization also improves environmental quality by reducing CO2 emissions through technology and knowledge transfers (Shahbaz et al. 2015a). For example, the use of cleaner technology by firms requires lesser energy and also helps them to have higher economic growth without hampering environmental quality. In addition, these trade, investment and technology channels have many implications for the environment and economic activity. First, if the country continues to release greater amounts of CO2 emissions due to rising production and consumption activity, it surely hampers environmental quality via increasing carbon emissions. Second, environmental degradation further depends on the nature of technology used in production and consumption activities. In this case, if firms use dirty energy-intensive production techniques, no doubt, economic growth is increased but it also degrades environmental quality along with making climate change and global warming to the extent of worse situation. Third, if an economy continues to be a net importer of energy, then energy imports can again aggravate its balance of payments, which in turn further affects its economic growth process in the long-run.

Another stream of literature paid more attention to the influence of globalization on CO_2 emissions. For instance, Shahbaz et al. (2017) determined the factors contributing to CO_2 emissions for Chinese economy. Considering the role of globalization in carbon emissions function, their empirical analysis indicated that globalization (economic, social and political) contributes to environmental quality in the presence of environmental Kuznets curve. Jin (2015) considers a multi-region global model to simulate the effects of different dimensions of globalization on carbon emissions in China. The Simulation results show that traditional economic globalization policies such as trade and foreign direct investment liberalization lead dioxide emission to rise through boosting production output. However, technology globalization – such as removal of technology transfer barriers - reduces energy emissions in China. Consequently, authorities in China should adopt the right globalization-based policies in order the effectively preserve good domestic environment conditions. Fernandez-Amador et al. (2016) assess CO_2 emissions embodied in international trade and found that international trade increases global CO_2 emissions following the trade openness rise of developing countries. Shahbaz et al. (2016c) incorporate globalization in the Environmental Kuznets curve in 19 African countries to determine the link between globalization and CO_2 emission in African countries. Their findings show that globalization reduces CO_2 emissions 8 out of 19 countries while it increases it in 5 out of 19 countries. Ertugrul et al. (2016) analyze the relationship between carbon dioxide emissions and trade openness in top ten emitter countries. Employing three different econometric techniques namely Andrews-Zivot unit root test with structural breaks, the bounds testing for cointegration in presence of structural breaks and VECM Granger causality test, the authors find evidence that real income, energy consumption and trade openness are the main drivers of carbon emissions in the sample countries. They also recommend that emerging countries should continue increase their real GDP as they found an inverted U-shaped relationship between economic growth and pollution in these countries. The authors conclude that trade openness coupled with economic growth contribute to environmental degradation in countries including China, Indonesia and Thailand. Doythch and Uctum (2016) analyze the impact of globalization, measured by capital inflows, on the environment using a large sample of countries over a long time span from 1984 to 2011. They argue that results are different according the industry receiving the foreign capital. Indeed, capital flows into manufacturing increase pollution while those into services preserve the environment from pollution. In addition, a different impact of capital flows on the environment is detected according the income level of countries in the sample. In fact, capital flows into low- and middle-income countries lead to the degradation of their environment while capital flowing into high-income countries benefits the environment. For Indian economy, Shahbaz et al. (2015) used index of globalization (economic globalization, social globalization and political globalization) developed by Dreher (2006) to examine the linkages between globalization and CO_2 emissions. Their results indicate that globalization detrimental effect on environmental quality. Ling et al. (2015) decomposed the trade-environment nexus using Malaysian data for the period of 1970-2011. They found that trade affects environmental quality via income, scale, composition and comparative effects. Their results show that income and comparative effects have positive effect on environmental degradation but scale and composition effects improve environmental quality. In case of Turkey, Shahbaz et al. (2013d) investigated the validation of environmental Kuznets curve in the presence of globalization. Their results show that globalization improves the environmental quality in the presence of environmental Kuznets curve.

Our previous review of the literature on how financial development and globalization clearly influence CO2 emissions indicates mixed findings on the issue. So far, no definite answer to this question was formulated. As for the methods, we have found none of studies in case of China considered the role of asymmetries while investigating the association between carbon emissions and its determinant. We contribute to the existing literature by considering a new measure of the financial development index and four dimensions of globalization. We also employ a nonlinear ARDL model that more flexible than linear models in that, first, it enables to disentangle effects of positive and negative shocks of financial development and globalization on CO2 emissions and second, it allows simultaneously variables having different orders of integration i.e. I(0) and I(1) variables.

3. Methodology and Data

Few studies in existing energy literature investigated the contributory factors to CO_2 emissions by applying different methods which provide conflicting empirical results for case of China. Following Jalil and Feridun (2011), Zhang (2011) and, Xiong and Qi (2017) and Shahbaz et al. (2017), we apply augmented carbon emissions function by incorporating financial development and globalization as additional determinants of CO_2 emissions for Chinese economy. Therefore findings of existing studies in literature are ambiguous due to ignorance of relevant variables such as financial development and globalization. It is indicated by Sardosky (2011) that financial development affects carbon emissions by business, consumer and technological effects. Similarly, globalization affects CO_2 emissions by scale, technological and composition effects (Shahbaz et al. 2015). This shows the importance of financial development and globalization to be incorporated in carbon emissions function to determine the major determinants of CO_2 emissions.

In doing so, we employ the NARDL model developed by Shin et al. (2014) to assess the asymmetric influence of economic growth, financial development and globalization on carbon emissions in China. A general version of the NARDL model that includes both long- and short-run asymmetries is specified as follows:

$$\Delta CO2_t = \mu + \rho_{CO2} CO2_{t-1} + \rho_{GDP}^{+} GDP_{t-1}^{+} + \rho_{GDP}^{-} GDP_{t-1}^{-} + \rho_{EC}^{+} EC_{t-1}^{+} + \rho_{EC}^{-} EC_{t-1}^{-} + \rho_{FD}^{+} FD_{t-1}^{+} + \rho_{FD}^{-} FD_{t-1}^{-} + \rho_{GLOB}^{+} GLOB_{t-1}^{+} + \rho_{GLOB}^{-} GLOB_{t-1}^{-} + \sum_{i=1}^{p-1} \alpha_i \Delta CO2_{t-i} + \sum_{i=1}^{q-1} (\beta_i^{+} \Delta GDP_{t-i}^{+} + \beta_i^{-} \Delta GDP_{t-i}^{-}) + \sum_{i=1}^{q-1} (\delta_i^{+} \Delta EC_{t-i}^{+} + \delta_i^{-} \Delta EC_{t-i}^{-}) + \sum_{i=1}^{q-1} (\gamma_i^{+} \Delta FD_{t-i}^{+} + \gamma_i^{-} \Delta FD_{t-i}^{-}) + \sum_{i=1}^{q-1} (\pi_i^{+} \Delta GLOB_{t-i}^{+} + \pi_i^{-} \Delta GLOB_{t-i}^{-}) + \varepsilon_t (1)$$

Where CO_2 stands for carbon dioxide emissions, GDP for gross domestic product, EC for energy consumption, FD for financial development and GLOB for globalization. We run the previous model in equation-1 separately for each dimension of globalization. The subscripts + and – designate respectively the partial sum processes of positive and negative changes of the variables. For the globalization variable $GLOB_t^{+}$ and $GLOB_t^{-}$ are defined as follow:

$GLOB_t^{+} = \sum_{i=1}^{t} \Delta GLOB_j^{+} = \sum_{i=1}^{t} \max(\Delta GLOB_j, 0)$ and

$$GLOB_t^{-} = \sum_{i=1}^{t} \Delta GLOB_j^{-} = \sum_{i=1}^{t} \min(\Delta GLOB_j, 0)$$

The long-run positive and negative coefficients can be calculated as $\theta_{GDP}^{+} = {}^{-\rho_{GDP}^{+}}/_{\rho_{CO2}}$ and $\theta_{GDP}^{-} = {}^{-\rho_{GDP}^{-}}/_{\rho_{CO2}}$, respectively for GDP; $\theta_{EC}^{+} = {}^{-\rho_{EC}^{+}}/_{\rho_{CO2}}$ and $\theta_{EC}^{-} = {}^{-\rho_{EC}^{-}}/_{\rho_{CO2}}$, respectively for EC; $\theta_{FD}^{+} = {}^{-\rho_{FD}^{+}}/_{\rho_{CO2}}$ and $\theta_{FD}^{-} = {}^{-\rho_{FD}^{-}}/_{\rho_{CO2}}$, respectively for FD and $\theta_{GLOB}^{+} = {}^{-\rho_{GLOB}^{+}}/_{\rho_{CO2}}$ and $\theta_{GLOB}^{-} = {}^{-\rho_{GLOB}^{-}}/_{\rho_{CO2}}$, respectively for globalization. The long-run symmetry of the influence of GDP, energy consumption, energy consumption, financial development and globalization are tested using the Wald test of the respective null hypotheses $\rho_{GDP}^{+} = \rho_{GDP}^{-}$, $\rho_{EC}^{+} = \rho_{EC}^{-}$, $\rho_{FD}^{+} = \rho_{FD}^{-}$ and $\rho_{GLOB}^{+} = \rho_{GLOB}^{-}$. Likewise, short-run symmetry of the respective impacts of GDP, financial development and globalization on dioxide carbon emissions is tested using the Wald test of the respective null hypotheses $\beta_i^{+} = \beta_i^{-}$,$\delta_i^{+} = \delta_i^{-}$,$\gamma_i^{+} = \gamma_i^{-}$and $\pi_i^{+} = \pi_i^{-}$ for $i = 1,2, \dots, q-1$.

Once asymmetry is detected – in the long-, short-run or both – it is possible to compute dynamic multipliers that give the predicted trajectory of CO_2 emissions following unit positive and negative unit changes of $GDP^{+}, GDP^{-}, EC^{+}, EC^{-}$, $FD^{+}, FD^{-}, GLOB^{+}$ and $GLOB^{-}$, respectively. For example, the dynamic multipliers following a unit change of $GLOB^{+}$ and $GLOB^{-}$ are computed as follows:

$$m_{GDP,h}^{+} = \sum_{j=0}^{h} \frac{\partial IP_{t+j}}{\partial GDP_t^{+}} \text{and } m_{GDP,h}^{-} = \sum_{j=0}^{h} \frac{\partial IP_{t+j}}{\partial GDP_t^{-}}\text{,respectively.}$$

Shin et al. (2014) show that $m_{GDP,h}^{+} \rightarrow \theta_{GDP}^{+}$ *and* $m_{GDP,h}^{-} \rightarrow \theta_{GDP}^{-}$ when $h \rightarrow \infty$. Figures (1) to (4) depict the computed dynamic multipliers following a unit shock of each of the regressands considered in our study.

Unavailability of data on globalization has restricted us to consider the period of 1970-2015 for empirical analysis. We have utilized World Development Indicators (CD-ROM, 2015) to collect data for CO_2 emissions (metric tons), real GDP (in constant 2010 local currency) measure for economic growth, energy use (kg of oil equivalent) proxy of energy consumption and real domestic credit to private sector (in constant 2010 local currency) measure for financial development. This study uses globalization index developed by Dreher (2006). Fundamentally, Dreher (2006) uses three sub-indices: economic globalization, social globalization and political globalization to generate index for globalization. Economic globalization is understood in the form of trade and capital inflows. Social globalization is also understood in the form of personal contacts, telephone contacts, tourism, and migration of people among countries, information flows i.e. internet usage, televisions per 1000 people, trade in newspapers, and data on cultural proximity (e.g., number of McDonald's restaurants, number of IKEA stores, trade in books). Finally, political globalization is described by the number of embassies in a country, membership in international organizations, participation in the UN secretary council membership and involvement in international treaties to generate an index of political globalization. From the point view of significance, the relative share in the overall globalization index contributed by economic globalization is 36% and followed by social globalization (38%) and by political globalization (26%). The weighted average overall globalization index and its sub-indices are created and maintained by ETH Zurich[5]. The total population series is used to transform all the variables into per capita units.

All studies investigated the determinants of CO_2 emissions by using annual frequency data but none of study used quarter frequency data while investigating the association between carbon emission and its determinants in case of China. It is clearly argued by Narayan and Sharma (2015), Phan et al. (2015a, b) and Hoang et al. (2015, 2016) that data frequency matters for empirical results. In doing so, we transform annual frequency data into quarter frequency data by employing quadratic match-sum method following Sbia et al. (2013). The quadratic match-sum method helps in avoiding the degree of freedom problem for small sample data. Moreover, Mack and Martinez-Garcia (2013) recommend for using the quadratic match-sum method while converting series from low to high frequency. This method seems to correct seasonal variations in the data.

4. Findings and analysis

Table-1 presents the Wald statistics and their corresponding p-values for the test that checks for the long-run (W_{LR}) and short-run (W_{SR}) asymmetry in the Nonlinear Autoregressive Distributed Lags (NARDL) model for the four considered dimensions of globalization namely economic globalization, social globalization, political globalization and overall globalization. The results show that in the long-run, the impact of gross domestic product growth (GDP) on CO_2 emissions is linear and symmetric regardless of the type of globalization introduced in the model except for economic globalization where the impact of GDP on CO_2 emissions is found to be nonlinear and asymmetric. Similarly, in the short-run, this relationship is linear and symmetric. As for energy consumption as explanatory variable, it impacts CO_2 emissions in a linear and symmetric fashion in the long-run. In contrast, energy consumption influences CO_2 emissions in an asymmetric and nonlinear manner in the short-run.

[5] For more details, see http://globalization.kof.ethz.ch/

Financial development, globally, it has a nonlinear and asymmetric impact on CO_2 emissions in the long-run when economic globalization is considered in the model. However, in models including social, political or overall globalization financial development impacts CO_2 emissions in a symmetric and linear manner in the long-run. In the short-run, financial development has a linear and symmetric impact on CO_2 emissions for all globalization dimensions.

Turning to the analysis of the fourth explanatory variable, individual dimensions of globalization, the computed Wald statistics show that, in the long-run, the relationship between economic globalization and CO_2 emissions is asymmetric and nonlinear while between social, political and overall globalization is found to be linear and symmetric. However, in the short-run, globalization variable impacts CO_2 emissions in a linear and symmetric fashion.

Table-1: Long-run and Short-run Asymmetry Test

	W_{LR}	W_{SR}
CO2		
GDP	11.600*** [0.001]	0.003 [0.957]
EC	2.028 [0.156]	9.109*** [0.003]
FD	13.180*** [0.000]	0.6001 [0.439]
EG	8.659*** [0.004]	0.002 [0.964]
CO2		
GDP	0.355 [0.552]	0.028 [0.867]
EC	0.106 [0.745]	6.888** [0.010]
FD	1.447 [0.231]	0.538 [0.464]
SG	0.539 [0.464]	0.233 [0.630]
CO2		
GDP	1.099 [0.296]	0.080 [0.777]

EC	0.260 [0.611]	4.798** [0.030]
FD	1.917 [0.168]	0.001 [0.977]
PG	0.874 [0.351]	0.833 [0.363]
CO2		
GDP	1.011 [0.316]	0.091 [0.763]
EC	0.098 [0.755]	7.803*** [0.006]
FD	2.055 [0.154]	0.076 [0.783]
OG	0.654 [0.420]	0.260 [0.611]
Notes: WSR and WLR refer to the Wald statistics for the short- and long-run symmetry null hypotheses. The numbers in the brackets are thep-values. *** Indicates rejection of the null of symmetry at 1%. ** Indicates rejection of the null of symmetry at 5%. * Indicates rejection of the null of symmetry at 10%.		

Table-2 exhibits results of the estimated NARDL models by globalization dimension i.e. economic, social, political and overall globalization. Findings show that the coefficients related to the lagged CO_2 emissions, of all the four selected globalization types, are negative and statistically significant at 1% significance level for all models indicating the stability of the estimated NARDL models. However, the one-period lagged changes in CO_2 emissions have strong significant positive impact on current CO_2 emissions in all models regardless of the globalization dimension. The current and one-period lagged GDP growths have significant respective positive and negative short-run impact on CO_2 emissions in the four considered models. The overall short-run effect of GDP variations, calculated as the sum of all short-run coefficients of GDP, on current CO_2 emissions is positive i.e. 0.141, 0.152, 0.152 and 0.157 in the respective models of economic, social, political and overall globalization. In the long-run, results show that increases of GDP rise CO_2 emissions in the presence of economic globalization while decreases of GDP reduce CO_2 emissions. The latter asymmetric long-run impact of GDP on CO_2 emissions clearly reveals that decreases of GDP have stronger effect on CO_2 emissions than increases of GDP. In model including social globalization increases and decreases of GDP significantly rise and reduce CO_2 emissions by the same magnitude[6]. This reveals that overall GDP has positive and significant effect on CO_2 emissions. This empirical

[6] However, in presence of political and overall globalizations GDP does not influence CO2 emission at all.

findings is similar with the studies of Jalil and Feridun (2011), Zhang (2011) and, Xiong and Qi (2017), which mention the contributory role of economic growth to environmental degradation.
In the long-run, energy consumption deteriorates the environment as more energy consumption leads more CO_2 emissions in China. Nevertheless, in the short-run consuming more energy entails more CO_2 emissions while reducing energy consumption leads to lower CO_2 emission of less magnitude in the case of social, political and overall globalization. Shahbaz et al. (2016), Ling et al. (2015), Shahbaz et al. (2013d) and Jalil and Feridun (2011) reported that energy consumption deteriorates environmental quality by adding in CO_2 emissions for Portugal, Malaysia, Turkey and China. In the economic globalization case, reducing energy consumption in the short-run does not reduce nor increase CO_2 emissions.

Financial development has increasing and decreasing impacts on long-run CO_2 emission via positive and negative shocks occurring in financial development when economic globalization is accounted for in the model. This indicates that an increase of financial development will lead CO_2 emissions to move down but opposite effect is noted in case of less financial development. Indeed, less financial development leads CO_2 emissions to move up with a stronger effect in the latter cases. Financial development does not impact CO_2 emissions in the long-run coupled with social, political or overall globalization. This shows that financial development affects carbon emissions insignificantly. This empirical evidence is consistent with Ozturk and Acaravci (2013) who noted that financial development does not affect carbon emissions for Turkish economy. This contrary is similar with Jalil and Feridun (2011), Zhang (2011) and, Xiong and Qi (2017) who reported that financial development improves environmental quality via lowering carbon emissions. Our findings show that the overall effect of financial development on CO_2 emission in the short-is significantly positive regardless of the type of globalization in the model.

Coming to the analysis of the effect of each of the considered globalization dimensions on CO_2 emission, our results show evidence of a nonlinear and asymmetric effect of economic globalization when considered in the model. Indeed, higher level of economic globalization will deteriorate environmental quality in the long-run while lower level of economic globalization will reduce CO_2 emissions with more pronounced effect in case of decrease the extend of economic globalization. Social and overall globalizations have significant negative long-run effects on CO_2 emissions meaning that higher levels of social and overall globalizations would preserve the environment from being deteriorated[7]. The negative effect of globalization (social and overall globalization) on carbon emissions is consistent with Shahbaz et al. (2017) who noted that globalization improves environmental quality by decreasing carbon emissions without affecting the pattern of EKC effect. Higher level of economic globalization increases carbon emissions is contrary with Shahbaz et al. (2017) who reported that economic globalization is negative linked with carbon emissions i.e. economic globalization contributes to environmental quality for Chinese economy[8]. However, in the short-run social, political and overall globalizations are found to reduce CO_2 emissions while economic globalization has no short-run influence on CO_2 emissions.

Table-2: Long-run and Short-run Asymmetric and Symmetric Analysis

CO2-EG		GDP-SG		GDP-PG		GDP-OG	
GDP, FD and EG LR asymmetry& EC SR asymmetry		EC SR asymmetry		EC SR asymmetry		ECSR asymmetry	
$CO2_{t-1}$	-0.058*** (0.014)	$CO2_{t-1}$	-0.046*** (0.012)	$CO2_{t-1}$	-0.027** (0.012)	$CO2_{t-1}$	-0.035*** (0.011)
GDP^{+}_{t-1}	0.029** (0.013)	GDP_{t-1}	0.016** (0.007)	GDP_{t-1}	0.004 (0.005)	GDP_{t-1}	0.010 (0.007)
GDP^{-}_{t-1}	-0.137*** (0.050)	EC_{t-1}	0.029** (0.011)	EC_{t-1}	0.023* (0.012)	EC_{t-1}	0.023* (0.012)
EC_{t-1}	0.037* (0.019)	FD_{t-1}	0.002 (0.003)	FD_{t-1}	0.002 (0.004)	FD_{t-1}	0.003 (0.003)
FD^{+}_{t-1}	-0.020** (0.008)	SG_{t-1}	-0.009*** (0.003)	PG_{t-1}	-0.006 (0.005)	OG_{t-1}	-0.014** (0.006)
FD^{-}_{t-1}	0.072*** (0.019)	$\Delta CO2_{t-1}$	0.568*** (0.062)	$\Delta CO2_{t-1}$	0.557*** (0.065)	$\Delta CO2_{t-1}$	0.565*** (0.064)
EG^{+}_{t-1}	0.045** (0.017)	ΔGDP_{t}	0.434*** (0.079)	$\Delta CO2_{t-4}$	-0.099** (0.049)	ΔGDP_{t}	0.373*** (0.084)
EG^{-}_{t-1}	-0.060*** (0.021)	ΔGDP_{t-1}	-0.282*** (0.083)	ΔGDP_{t}	0.339*** (0.093)	ΔGDP_{t-1}	-0.216** (0.087)
$\Delta CO2_{t-1}$	0.488*** (0.068)	ΔEC^{+}_{t}	1.026*** (0.088)	ΔGDP_{t-1}	-0.214** (0.095)	ΔEC^{+}_{t}	1.089*** (0.093)
ΔGDP_{t}	0.443***	ΔEC^{+}_{t-1}	-0.542***	ΔEC^{+}_{t}	1.047***	ΔEC^{+}_{t-1}	-0.587***

[7] Being insignificant, the effect of political globalization on CO_2 emissions shows a similar pattern, i.e. political globalization reduces CO_2 emissions but it is insignificant.
[8] This difference in empirical findings shows the importance of asymmetries occurred in times series data to be considered while investigating the determinants of carbon emissions.

	(0.084)		(0.106)		(0.103)		(0.114)
ΔGDP_{t-1}	-0.302*** (0.087)	ΔEC_t^-	0.242* (0.143)	ΔEC_{t-1}^+	-0.569*** (0.120)	ΔEC_{t-1}^-	-0.370** (0.144)
ΔEC_t^+	0.866*** (0.089)	ΔEC_{t-1}^-	-0.373** (0.145)	ΔEC_{t-1}^-	-0.272* (0.151)	ΔFD_t	0.079*** (0.021)
ΔEC_{t-1}^+	-0.329*** (0.110)	ΔFD_t	0.063*** (0.020)	ΔFD_t	0.087*** (0.022)	ΔFD_{t-1}	-0.048** (0.021)
ΔFD_t	0.072*** (0.022)	ΔSG_t	-0.073*** (0.015)	ΔFD_{t-1}	-0.055** (0.022)	ΔOG_t	-0.195*** (0.038)
constant	-0.081*** (0.021)	ΔSG_{t-1}	0.056*** (0.015)	ΔPG_t	-0.134*** (0.036)	ΔOG_{t-1}	0.153*** (0.040)
		Constant	-0.065*** (0.017)	ΔPG_{t-1}	0.097** (0.038)	constant	-0.048*** (0.016)
				constant	-0.035** (0.016)		
L_{GDP^+}	0.510* [0.054]	L_{GDP}	0.359** [0.019]	L_{GDP}	0.169 [0.428]	L_{GDP}	0.307 [0.156]
L_{GDP^-}	-2.360*** [0.003]	L_{EC}	0.635*** [0.000]	L_{EC}	0.859*** [0.000]	L_{EC}	0.666*** [0.002]
L_{EC}	0.646*** [0.003]	L_{FD}	0.046 [0.510]	L_{FD}	0.070 [0.598]	L_{FD}	0.095 [0.303]
L_{FD^+}	-0.348** [0.035]	L_{SG}	-0.192*** [0.001]	L_{PG}	-0.244 [0.270]	L_{OG}	-0.404** [0.048]
L_{FD^-}	1.248*** [0.000]						
L_{EG^+}	0.788*** [0.005]						
L_{EG^-}	-1.038** [0.031]						
AIC	-1340.491	AIC	-1370.411	AIC	-1336.594	AIC	-1358.486
SIC	-1270.246	SIC	-1312.838	SIC	-1272.847	SIC	-1297.820
Q(40)	36.630 [0.622]	Q(40)	49.000 [0.155]	Q(40)	43.550 [0.323]	Q(40)	48.100 [0.177]

Notes: Only significant short-run coefficients are reported in this Table 2. Standard errors of the estimated coefficients are in parenthesis. The p-values of statistical tests are in brackets. LX^+ and LX^- indicate the positive and negative long-run coefficients, respectively. Lag orders of the three NARDL models are selected according to the Akaike and Schwarz Information criteria. p = 5, q = 2 for CO2-PG ; p =4, q = 2 for CO2-EG and CO2-OG; p = 3, q = 2 for CO2-SG.Q(40) refers to the Ljung-Box test of the null of independent residuals up to lag 40.
*** Indicates significance at 1%.
** Indicates significance at 5%.
* Indicates significance at 10%.

Figures 1 to 4 depict the dynamic multipliers of the four models. Each model includes gross domestic product, energy consumption, financial development and one of the four globalization dimensions considered namely economic globalization, social globalization, political globalization and overall globalization. The asymmetry curve shows a linear combination of the dynamic multipliers associated with positive and negative shocks. The positive change and negative change curves indicate the adjustment paths after a positive and a negative change at a given forecasting horizon, respectively. The lower and upper bands indicate a 95% confidence interval for asymmetry.

The shape of the dynamic multipliers of the effect of GPD on CO_2 emission changes across models. Indeed, in all four models it reveals that unitary shock to GDP implies a long-run response of CO_2 emissions that lasts approximately 20 quarters, and then the level of CO_2 emissions stabilizes with a lower reaction of CO_2 emissions in model including political globalization. The asymmetry curve showing the reaction of CO_2 emissions to a unit shock of energy consumption shows a similar pattern in the four estimated models. Indeed, after a quick increase of CO_2 emissions following a unit shock of energy consumption that lasts around two quarters CO_2 emissions level starts decreasing and vanishes after ten quarters.

Similarly, CO_2 emissions reaches a new equilibrium after roughly 20 quarters after a positive or a negative unitary shock to financial development occurs in models with social, political or overall globalization. However, when economic globalization is included in the model both unitary positive and negative shocks of financial development have negative impacts on CO_2 emissions leading to a negative asymmetry curve that stabilizes after around 18 quarters ahead. Turning to the effect of globalization on CO_2 emissions, the dynamic multipliers graphs show that the reaction of CO_2 emissions to positive and negative unitary changes in economic globalization is positive intensifying thus the asymmetry curve that is positive and stabilizes at the 1.7 level after around 18 quarters. Reactions of CO_2 emissions to social, political and overall globalization show similar patterns. Indeed, a unitary positive shock of economic (social) globalization shows a low positive effect on CO_2 emissions has a negative effect on CO_2 emissions while a negative unitary shock produces a positive effect of similar size on CO_2 emissions. Consequently, asymmetry path is null in the three previous cases.

Figure-1. Dynamic Multipliers for CO2-EG

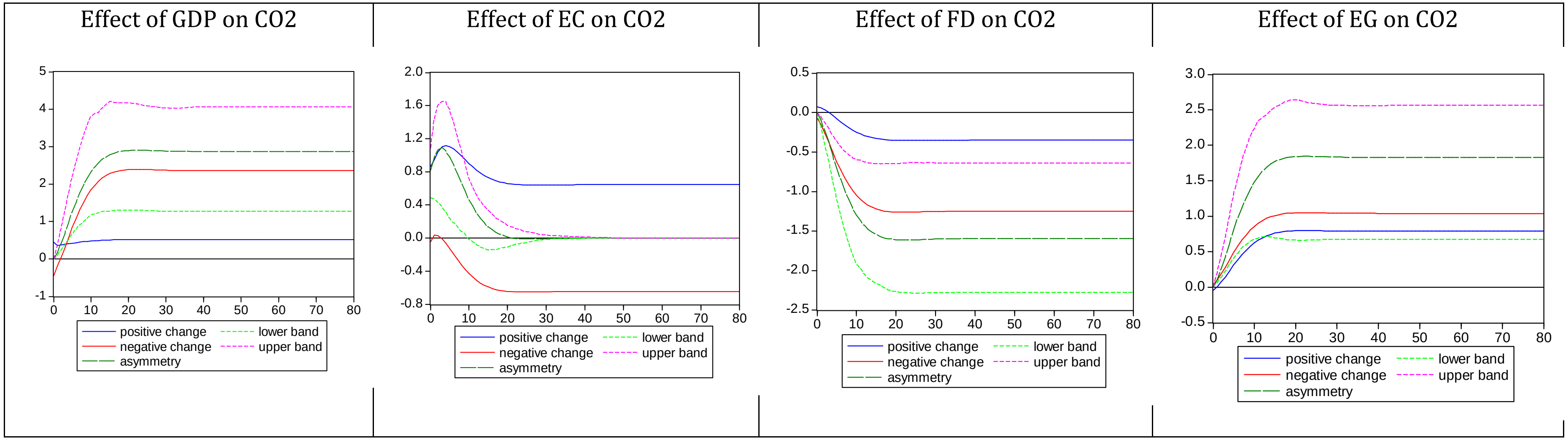


Figure-2. Dynamic Multipliers for CO2-SG

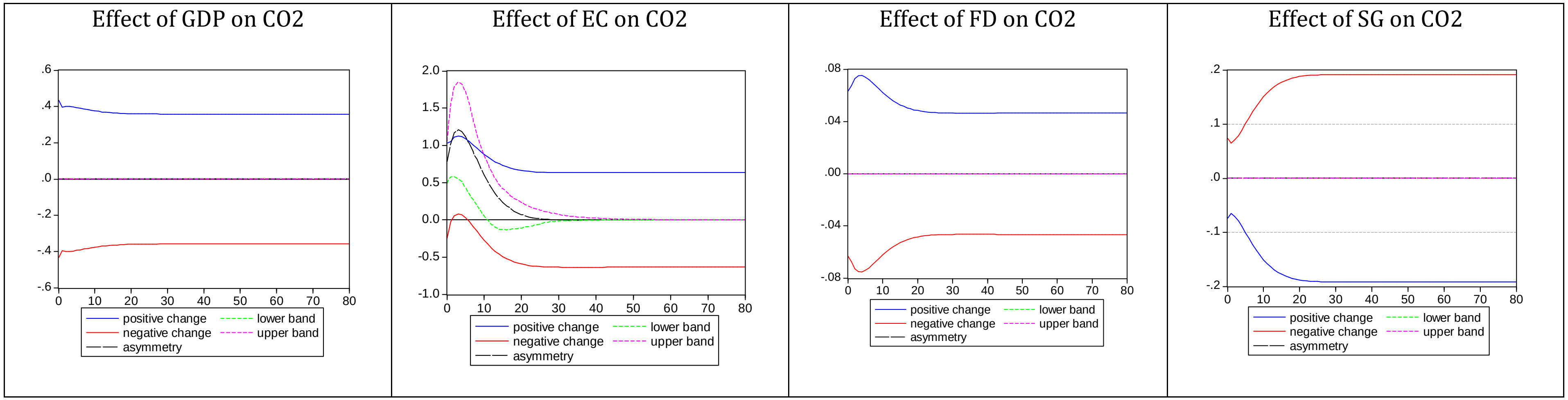


Figure-3: Dynamic Multipliers for CO2-PG

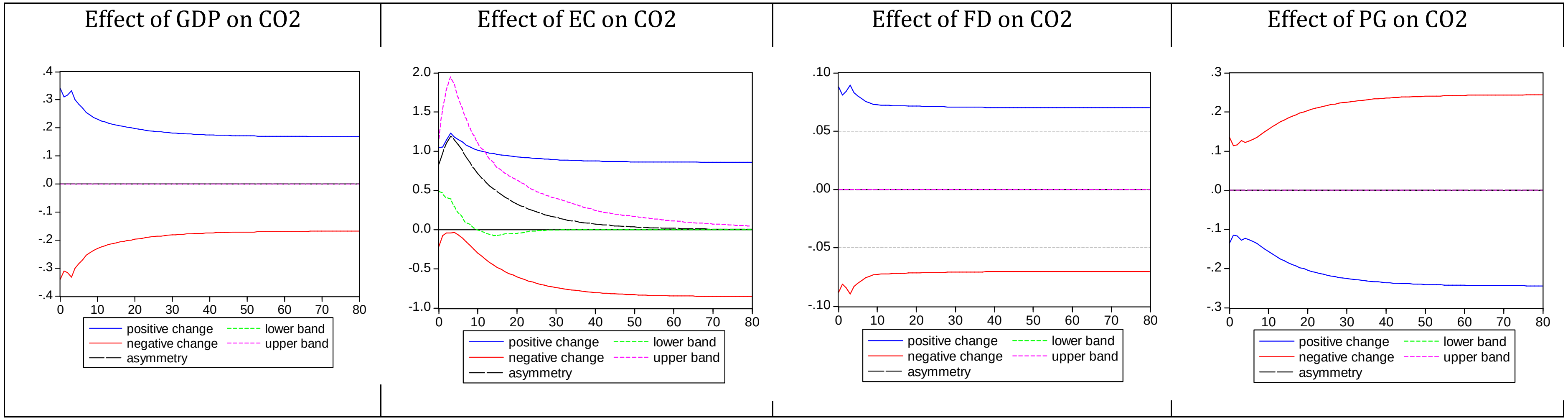
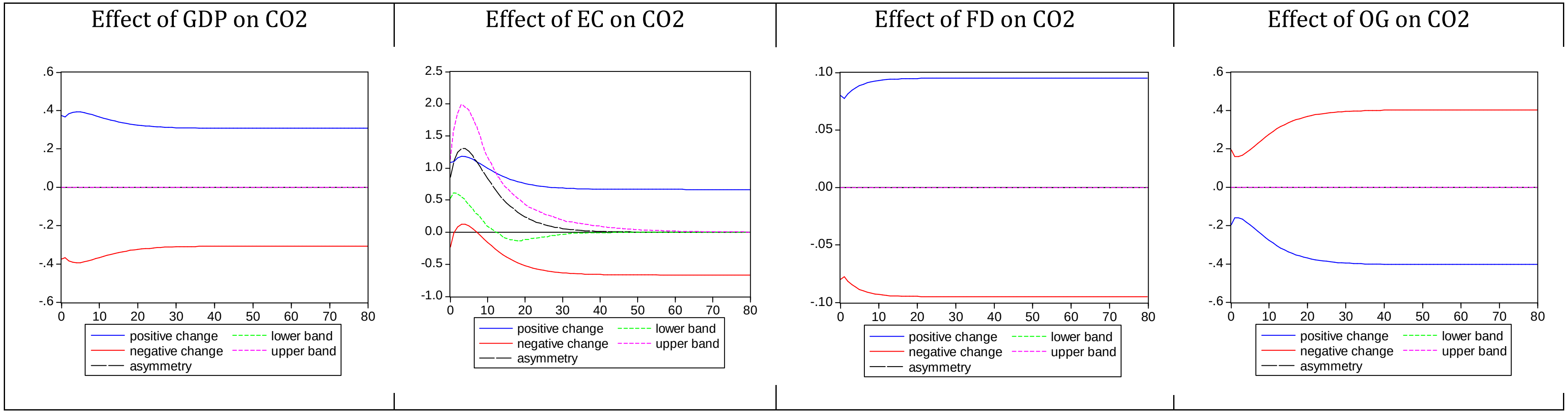


Figure-4: Dynamic Multipliers for CO2-OG



5. Conclusion and Policy Implications

The environment has experienced a substantial increase of dioxide carbon emissions which have nocuous effects on it in general and on households living conditions and health in particular. This enormous risk of environment degradation has led researchers and environment policy makers to concentrate on this topic in order to find appropriate solutions and adopt convenient policies. Nevertheless, reducing dioxide carbon emissions is still a challenge for several countries as the empirical findings regarding its determinants and their relationships with the level of carbon dioxide issued in the environment provide mixed results. Hence no clear definite answer on the influence of CO_2 emissions drivers on environment is set. We contribute to the existing literature on determinants of CO_2 emissions and their influence on it by analyzing the influence of four main drivers that we believe are extremely important within a nonlinear framework. To do so, we employ the NARDL model that is shown in previous studies to beat its linear counterpart i.e. the linear ARDL model. Indeed, even though the simple ARDL model accounts for the cointegrating relationships that may exist between CO_2 emissions and its determinants it fails to disentangle the effects of positive and negative shocks on CO_2 emissions as it assumes similar size to positive and negative shocks. Thus, the ARDL model allows for symmetric effects of positive and negative shocks. In contrast, the NARDL model permits to detect the asymmetric effects of positive and negative shocks of exogenous variables on CO_2 emissions both in the long-run and short-run. In addition, the NARDL model allows predicting the future effects of positive and negative shocks hitting the system equations by computing dynamic multipliers. Interestingly, findings show, (1) In the short-run, gross domestic product, energy consumption, financial development and globalization affect significantly CO_2 emissions; (2) In the long-run, energy consumption significantly deteriorates environment. However, in the short-run, more energy consumption increases CO_2 emissions while less energy consumption preserves environment; (3) In the long-run, economic globalization influences carbon dioxide emissions in asymmetric and nonlinear manners while social and overall globalizations reduce CO_2 emissions in a linear. Thus, higher level of economic globalization raises CO_2 emissions while lower level reduces CO_2 emissions. However, political globalization does not impact CO_2 emissions; (4) In the short-run, economic globalization does not impact CO_2 emissions. However, social, political and overall globalizations reduce CO_2 emissions and; (5) Financial development asymmetrically impacts dioxide carbon emissions only when it coupled with economic globalization. It does not exert any influence on dioxide carbon emissions if coupled with social, political or overall globalization. These empirical findings are important for forecasters, investors and environmental policy makers who should consider the findings of the present research when formulating their investment decisions based on forecasts of the future evolution of environmental conditions and the related regulatory laws taken by the environmental deciders. This paper examines CO_2 emissions in China at the aggregate level. Future studies should aim at investigating the drivers of CO_2 emissions at the provincial and sectoral level in China, given the differences in energy consumption, financial development, globalization and economic growth level across provinces in China.

References

Abbasi, F., Riaz, K. (2016). CO_2 emissions and financial development in an emerging country: An augmented VAR approach. Energy Policy 90, 102-114.

Astöm, S., Tohka, A., Bak, J., Lindblad, M., Arnell, J. (2013). Potential impact on air pollution from ambitious national CO2 emission abatement strategies in the Nordic countries – environmental links between the UNFCCC and the UNECE – CLRTAP. Energy Policy 53, 114-124.

Boutabba, M. A. (2014). The impact of financial development, income, energy and trade on carbon emissions: Evidence from the Indian economy. Economic Modelling 40, 33-41.

Charfeddine, L., Khediri, K. B. (2016). Financial development and environmental quality in UAE: Cointegration with structural breaks. Renewable and Sustainable Energy Reviews, 55, 1322-1335.

Dogan, E., Seker, F. (2016). Determinants of CO_2 emissions in the European Union: the role of renewable and non-renewable energy. Renewable Energy 94, 429-439.

Dogan, E., Seker, F. (2016). The influence of real output, renewable and non-renewable energy, trade and financial development on carbon emissions in the top renewable energy countries. Renewable and Sustainable Energy Reviews 60, 1074-1085.

Doytch, N., Uctum, M. (2016). Globalization and the environmental impact of sectoral FDI. Economic Systems, http://dx.doi.org/10.1016/j.ecosys.2016.02.005.

Dreher, A. (2006). Does globalization affect growth? Evidence from a new index of globalization. Applied Economics 38, 1091-1110.

Ertugrul, H. M., Cetin, M., Seker, F., Dogan, E. (2016). The impact of trade openness on global carbon dioxide emissions: Evidence from the top ten emitters among developing countries. Ecological Indicators 67, 543-555.

Farhani, S., Ozturk, I. (2016). Causal relationship between CO_2 emissions, real GDP, energy consumption, financial development, trade openness, and urbanization in Tunisia. Environmental Science and Pollution Research 22, 15663-15676.

Fernandez-Amador, O., Francois, J. F., Tomberger, P. (2016). Carbon dioxide emissions an international trade at the turn of the millennium. Ecological Economics 125, 14-26.

Henneman, L. R. F., Rafaj, P., Annegarn, H. J., Klausbruckner, C. (2016). Assessing emissions levels and costs associated with climate and air pollution policies in South Africa. Energy Policy 89, 160-170.

Hoang, T., Lahiani, A., Heller, D., 2016. Is gold a hedge against inflation? A nonlinear ARDL analysis. *Economic Modelling* 54, 54-66.

Hoang, T., Wong, W.K., Zhu, Z.Z., 2015. Is gold different for risk-averse and risk-seeking investors? An empirical analysis of the Shanghai Gold Exchange. *Economic Modelling* 50, 200-211.

IPCC, 2007. Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Geneva, Switzerland.

Jalil, A, Feridun, M. (2011). The impact of growth, energy and financial development on the environment in China: A cointegration analysis. Energy Economics 33, 284-291.

Javid, M., Sharif, F. (2016). Environmental Kuznets curve and financial development in Pakistan. Renewable and Sustainable Energy Reviews 54, 406-414.

Katircioglu, S. T., Taspinar, N. (2017). Testing the moderating role of financial development in an environmental Kuznets curve: empirical evidence from Turkey. Renewable and Sustainable Energy Reviews 68, 572-586.

Kim, J., Park, K. (2016). Financial development and deployment of renewable energy technologies. Energy Policy 59, 238-250.

Lin. B., Omoju. O. E., Okonkwo. J. U. (2016). Factors influencing renewable electricity consumption in China. Renewable and Sustainable Energy Reviews 55, 687-696.

Ling, C. H., Ahmed, K., Muhamad, R. B. and Shahbaz, M. (2015). Decomposing the trade-environment nexus for Malaysia: what do the technique, scale, composition, and comparative advantage effect indicate? Environmental Science and Pollution Research 22, 20131-20142.

Mack, A., Martinez-Garcia, E., 2013. *A cross-country quarterly database of real house prices: A methodological note*. Federal Reserve Bank of Dallas, Working Paper n° 99.

Moomaw W, Yamba F, Kamimoto M, Maurice L, Nyboer J, Urama K, Weir T. (2011). Introduction. In: Edenhofer O, Pichs-Madruga R, Sokona Y, Seyboth K, Mat- schoss P, Kadner S, Zwickel T, Eickemeier P, Hansen G, Schlomer S, von Ste-chow C, editors. IPCC special report on renewable energy sources and climate change mitigation. New York: Cambridge University Press; 2011.

Narayan, P.K., Sharma, S.S., 2015. Does data frequency matter for the impact of forward premium on spot exchange? *International Review of Financial Analysis* 39, 45-53.

Nasreen, S., Anwar, S., Ozturk, I. (2017). Financial stability, energy consumption and environmental quality: evidence from South Asian economies. Renewable and Sustainable Energy Reviews 67, 1105-1122.

Ozturk, I., Acaravci, A. (2013). The long-run and causal analysis of energy, growth, openness and financial development on carbon emissions in Turkey. Energy Economics 36, 262-267.

Ozturk, I., Acaravci, A. (2013). The long-run causal analysis of energy, growth, openness and financial development on carbon emission in Turkey. Energy Economics 36, 262-267.

Phan, D.H.B., Sharma, S.S., Narayan, P.K., 2015a. Stock return forecasting: some new evidence. *International Review of Financial Analysis* 40: 38-51.

Phan, D.H.B., Sharma, S.S., Narayan, P.K., 2015b. Oil price and stock returns of consumers and producers of crude oil. *Journal of International Financial Markets, Institutions and Money* 34, 245-262.

Salahuddin, M., Gow, J., Ozturk, I. (2015). Is the long-run relationship between economic growth, electricity consumption, carbon dioxide emissions and financial development in Gulf Cooperation Council Countries robust? Renewable and Sustainable Energy Reviews 51, 317-326.

Sbia, R., Shahbaz, M. and Hamdi, H., 2014. A contribution of foreign direct investment, clean energy, trade openness, carbon emissions and economic growth to energy demand in UAE. *Economic Modelling* 36, 191–197.

Sehrawat, M., Giri, A. K., Mohapatra, G., (2015). The impact of financial development, economic growth and energy consumption on environmental degradation. Management of Environmental Quality: An International Journal, 26, 666- 682.

Shahbaz, M., Hye, Q. M. A., Tiwari, A. K., Leitao, N. C. (2013b). Economic growth, energy consumption, financial development, international trade and CO_2 emissions in Indonesia. Renewable and Sustainable Energy Reviews 25, 109-121.

Shahbaz, M., Jam, F. A., Bibi, S. and Nanthakumar, L. (2016a). Multivariate Granger causality between CO2 emissions, energy intensity and economic growth in Portugal: evidence from cointegration and causality analysis. Technological and Economic Development of Economy, 22, 47-74.

Shahbaz, M., Khan, S., Ali, A. and Bhattacharya, M. (2017). The impact of globalization on CO_2 emissions in China. Singapore Economic Review, 62, 1-29.

Shahbaz, M., Mallick, H., Mahalik, M. K. and Nanthakumar, L. (2015). Does globalization impede environmental quality in India? Ecological Indicators 52, 379-393.

Shahbaz, M., Ozturk, I., Afza, T. and Ali, A. (2013d). Revisiting the environmental Kuznets curve in a global economy. Renewable and Sustainable Energy Reviews 25, 494-502.

Shahbaz, M., Shahzad, S. J. H., Ahmad, N. and Alam, S. (2016b). Financial development and environmental quality: The way forward. Energy Policy 98, 353-364.

Shahbaz, M., Solarin, S. A., Mahmood, H. and Arorui, M. (2013c). Does financial development reduce CO2 emissions in Malaysian economy? A time series analysis. Economic Modelling 35, 145-152.

Shahbaz, M., Solarin, S. A., Ozturk, I. (2016c). Environmental Kuznets curve hypothesis and the role of globalization in selected African countries. Ecological Indicators 67, 623-636

Shahbaz, M., Tiwari, A. K., Nasir, M. (2013a). The effects of financial development, economic growth, coal consumption and trade openness on CO_2 emissions in South Africa. Energy Policy 61, 1452-1459.

Tamazian, A., Chousa, J. P., Vadlamannati, K. C. (2009). Does higher economic and financial development lead to environmental degradation: Evidence from BRIC countries. Energy Policy 37, 246-253.

Xiong, L., Qi, S. (2017). Financial development and carbon emissions in Chinese Provinces: A spatial panel analysis. Singapore Economic Review 62, 1-18.

Zhang, Y. J. (2011). The impact of financial development on carbon emissions: An empirical analysis in China. Energy Policy 39, 2197-2203.