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Revisiting the emissions-energy-trade nexus: Evidence from the newly industrializing countries

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Abstract:

This paper applies Pedroni's panel cointegration approach to explore the causal relationship between trade openness, carbon dioxide emissions, energy consumption and economic growth for the panel of newly industrialized economies (i.e. Brazil, India, China and South Africa) over

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the period of 1970–2013. Our panel cointegration estimation results found majority of the variables cointegrated and confirm the long-run association among the variables. The Granger causality test indicates bi-directional causality between carbon dioxide emissions and energy consumption. A uni-directional causality is found running from trade openness to carbon dioxide emission and energy consumption, and economic growth to carbondioxide emissions. The results of causality analysis suggest that the trade liberalization in newly industrialized economies induces higher energy consumption and carbon dioxide emissions. Furthermore, the causality results are checked using an innovative accounting approach which includes forecast-error variance decomposition test and impulse response function. The long-run coefficients are estimated using fully modified ordinary least square (FMOLS) method and results conclude that the trade openness and economic growth reduce carbon dioxide emissions in the long-run. The results of FMOLS test sound the existence of environmental Kuznets curve hypothesis. It means, trade liberalization induces carbon dioxide emission with increased national output, but it offsets that impact in the long-run with reduced level of carbon dioxide emissions.

Key Words: Newly industrialized economies; Gross domestic production (GDP); Carbon dioxide emissions; Trade liberalization; Energy consumption

1. Introduction

Over the last few decades, the global economy has observed spectacular growth trend. This growth trend is mainly associated with the liberalization of trade started with the establishment of GATT[2] and later WTO[3]. The reduced trade barriers and technological advancement not only contributed to growth in trade, but also increased gross world production. Trade induced

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[2] General Agreement on Trade and Tariffs (GATT) came in to force on January 1, 1948.

[3] World Trade Organization (WTO) commenced on January 1, 1995 under Marrakesh Agreement and replaced GATT

globalization allowed both the developing and developed economies to grow at a faster pace. Whilst many of the developing and emerging economies have been successful in achieving their socio-economic goals by opening their borders for trade, some of these developing economies even grew exceptionally fastest among their peers. In 2013, these newly industrializing countries account more than half of the world GDP (IMF, 2013). The group of these countries is referred as BICS[4]. BICS combines holds around 38% of world population, accounts 17% of world gross domestic production (GDP) and overall represents 16% of the world economy. However, this rapid growth trend has come along with severe environmental consequences. The exciting industrial expansion resulting from the decades-long consistent export led growth policy enables BICS to become a global manufacturing engine of today. Fig-1 demonstrates the BICS' increasing proportion in world merchandise trade, which rose from US$ 250 billion dollars in 1995 to nearly US$ 3 trillion dollars in 2013. Thus, such an enormous contribution in world aggregate output demands for higher energy resources followed by a substantial carbon dioxide (CO_2) emissions. Fig. 2 shows an increasing CO_2 emissions trend during the same period in BICS countries. If the similar growth trend is continued, the developing countries are projected to share 72% of global emissions by 2030 (World Bank, 2008). In addition, the primary energy consumption is expected to grow by 61% in BICS region alone (OECD, 2008). Per contra, the global efforts towards multilateral agreements on climate change and trade-environment policies are facing consecutive failure and major opposition is coming from these newly industrialized countries. The literature on the trade-environment nexus is divided into two main streams, the trade proponent and trade antagonist. The first group believes that the strategies to address the ongoing global environmental challenge lie within trade because, the trade openness leads to cleaner production with technological dissemination among advanced and developing economies

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[4] BICS (Brazil, India, China, South Africa)

with reduced cost and efficient resource allocation by using the comparative advantage. The latter holds an opinion that today's rising environmental challenges are the consequence of trade dominated globalization of the past few decades. However, the question whether the trade detriment environment or not is still contesting.

The plethora of literature study the trade-environment nexus, but the empirical evidences are either mix or inconclusive. The results vary country to country, region to region and as per income levels. Therefore, the study of the links between trade openness and CO_2 emissions in the presence of energy consumption and economic growth as an explanatory variables has been of primary interests to a wide range of scholarly community. Similarly, the main motivation for us to conduct this study is also to contribute to the existing literature. Doing so, this paper investigates the relationship between trade openness and CO_2 emissions by incorporating energy consumption and economic growth as potential determinants playing key role in the CO_2 emission function while taking the case of newly industrialized BICS countries.

Fig-1 and Fig-2 paste here

It is mutually agreed point between development and environmental researchers that growing environmental degradation due to increasing emissions is the main cause of harming earth's health. This continued trend will have unrecoverable implications for ecology and biodiversity as a whole. Therefore, the economy's goal now is not to just attain the higher production, but also to achieve the sustainable development goal. Sustainable development is directly associated with the use of sustainable and renewable energy resources based on newer technology. The free movement of such technological resources needs sufficient trade openness between economies.

This thread is actually a conceptual development that literature up to date has suggested. The literary debate on the relationship between trade openness and environmental degradation is over a decade long and the deliberation encompasses both the qualitative and quantitative studies. However, consensus is yet to achieve (Cole and Elliott, 2003). There are a number of empirical studies on the relationship of trade-environment-growth nexus (Cole and Elliott, 2003; Frankel and Rose, 2005; Managi et al. 2008), but very few are based on a the theoretical framework (Antweiler et al. 2001; Copeland and Taylor, 2004). The trade and environmental economist are still at the crossroads of deciding what exactly cause what in an economy because of the contradictory results (Zaman et al., 2011; Shahbaz et al., 2014). The recent literature mainly suggests that either single economy analysis or economies belonging to similar income level are most suitable to analyze trade-environmental-growth nexus. Hence, the results of such studies are more reliable for policy use. The argument that trade liberalization support efficient use of resources while contributing sustainable growth could make an essential contribution towards improved environmental conditions. But the question whether the structural transition in BICS allows trade openness to counter negative environmental implications over the time, formulates a real research question and we try to address it through this study.

The BICS countries are the current manufacturing hub of the world. Their contribution towards global production has extensively increased. Similarly, the future projections regarding their energy consumption and emissions trend have severe consequences on the global environmental externality. For example: Fig-3 below shows the trend in the variables for each cross-section country and one can clearly observe strong positive correlation between GDP, trade openness, energy consumption and CO_2 emissions. Moreover, in the absence of significant multilateral agreement on the climate change necessitate to further explore the literary work. Using CO_2

emissions as the function of trade openness, energy consumption and economic growth- this study undertakes an empirical investigation that how trade liberalization effect emission intensity in case of BICS countries. We adopt robust Pedroni's panel cointegration approach to cointegration over the extended period 1970-2013. This econometric approach tells us the individual relationship of all cointegrating vectors and also the relationship of the endogenous variable with underlying control variables. The long-run association among variables is also checked using FMOLS model. The sensitivity of the model is also checked using diagnostic test to see the stability and fitness of the model.

Fig-3 paste here

The endogenous variable tells us possible how GHG emissions and why we choose several empirical studies have been conducted on the relationship between trade openness and environmental degradation. However, there are very few empirical studies on environmental degradation based on theoretical framework. The trade economists and environmentalists argue that liberalization of trade through the efficient use of resources and sustaining growth could make an essential contribution towards creating the conditions necessary for environmental improvements. They also argue that trade liberalization and environmental policies will generate benefits through improving allocative efficiency, correcting market failures, and strengthening the potential of internalization of environmental instruments. In fact, the wealth created by trade liberalization will also improve the quality of life and eliminate poverty, which has been considered as an underlying cause of environmental degradation in many developing countries. The evidences of trade openness on environmental degradation from individual countries vary according to their income levels and this may happen due to difference in policy, economic structure, level of economic openness and country specific variations (Baek et al., 2009; Naranpanawa, 2011; Wiebe et al. 2012; Mudakkar et al., 2013; Forslid et al., 2014; Ozturk, 2015; Khan et al., 2016).

The most worrying thing about this stage is the conflict oriented situation between trade and climate economists. The policy deadlock between high and low income countries is widening as table talks suffer more failures. It is projected that the advance countries will limit the trade of lower income countries to control carbon leakages. As discussed by Messerlin (2010); Ahmed and Long (2013b) trade and climate change policies are interdependent and due to the global externality effect, the trade-climate policies will either suffer from mutual destruction or mutual construction. Consequently, the unilateral measures towards trade restriction from advanced economies to emerging economies would result in division of global economies in clean and dirty production heavens. The neoclassical model theoretically defines that how trade liberalization expands cleaner and dirty production due to income differences. It implies that the environmental impacts of trade opening are opposite on high and low income countries (for more details see Copeland and Tylor, 1995). There is series of literature available on the single country analysis of trade-and CO_2 emissions nexus, but to assist global surge towards multilateral agreement on climate change policy using the world trading system requires meta-analysis. During the upcoming trade-climate negotiations, the regional and income leveled group of countries will have more importance. Similarly, the adoption of the trade-environment policy will also be based on group of countries not unilateral. Therefore, this notion suggests that there is need of panel data analysis on the relationship of trade openness and CO_2 emissions. In order to fill such literary gap, this study utilizes panels of high, middle and low income countries to empirically examine the causal behavior of trade openness and CO_2 emissions. The most appropriate technique for panel cointegration proposed by Pedroni (1999) is incorporated with Granger causality approach of Engle and Granger (1987) to find out causal relationships between trade openness and CO_2 emissions for underlined panels.

The remaining paper is divided as; section (2), presents in brief literature review; section (3), is methodological framework; section (4), discusses the results; and section (5), presents the conclusion and policy recommendations. The findings of this paper are highly significant and possess deep policy implications for countries included in the panels, international trade and environmental agencies, regional economic blocks and researchers. This study opens future directions as well.

2. Review of Relevant Literature

The trade-environment-growth nexus is emerged with the concept of environmental Kuznets's curve (EKC) hypothesis in early 1990's. The concept of EKC is derived from the work of Simon Kuznets, 1955 who explored that there is inverted-U shaped relationship between income and inequality. He proposed with initial economic growth, inequality rises, but after certain threshold point inequality diminishes. The same is replicated for the environment and growth nexus. The seminal study of Grossman and Krueger (1991) first examined the environmental consequence of NAFTA[5] using the EKC hypothesis and opened the new research direction in the relationship of economic growth and the environment. However, the EKC hypothesis are widely accepted and used in many scholarly literature soon after the Earth summit[6] held in Rio-de-Janeiro (Brazil) and subsequent contribution of Shafik and Bandyopadhyay (1992) in the background study for

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[5] North American Free Trade Agreement (NAFTA)

[6] Also known as Rio-Summit organized by United Nations at Rio-de-Janeiro (Brazil) from 3~14 June, 1992

the World Development Report (1992) granted more recognition to EKC. The report concluded that the environmental quality is an essential indicator of sustainable development. Later, the concept of the EKC is widely accepted and further indicators of growth and environment are investigated (David Stern, 2004). The literature on trade, environment and growth are further advanced with the use of pollution haven hypothesis (Eskeland Harrison, 2003; Kearsley and Riddel, 2010). However, the results of both the studies on the EKC hypothesis and pollution hypothesis remained inconclusive whether trade contributes to lower environmental quality (for EKC hypothesis see, Grossman and Krueger, 1991; Shafik, 1994; Soytas et al., 2007; Ang, 2007 and pollution haven hypothesis see, Copeland and Taylor, 2004; Kearsley and Riddel, 2010). On the other hand, Frankle and Rose, (2005) found positive and statistically significant correlation between trade openness and measures of environmental quality (NO_2 and SO_2) but using the same technique Kellenberg, (2008) found mixed evidence on the relationship between trade openness and four pollutants ($NO_{2,}$ $SO_{2,}$ CO_2 and VOCs). But the connection between trade openness and environmental degradation seems to be mostly influenced by economic structure, level of income and quantitative technique adopted in the studies. First, on the basis of economic structure the study of Antweiler et al., (2001) explored the trade-environment nexus in terms of three broad categories[7] involved in production processes; scale, technique and composition effects. Keeping in view of the environmental repercussions of trade openness, the composition effect dominates the scale effect and technique effect dominates both scale and composition effect. It means the economy in which scale effect is dominating has the largest tendency of emissions intensive growth. Composition effect lies in the middle and technique effect is the least emissions intensive, hence, contribute to the cleaner production (for more details on the

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[7] These three categories were identified by Grossman and Krueger, (1993) and explained by Lopez, (1994) that growth in the economy can be observed due to the prevalence of these effects.

scale, composition and technique effect refer; Grossman and Krueger, 1993; Lopez, 1994). The further evidence from Kahuthu (2006) based on the methodological framework of Shafik and Bandyopadhyay (1992), and Selden and Song (1994) found that composition effect of trade openness could have positive or negative environmental consequences depending on the relative size of capital-labor effect and existing environmental regulations in the economy.

Secondly, the study of Frankel (2008) analyzes the same income level sample test on SO_2 emissions, trade openness and economic growth and found results quite similar to Grossman and Krueger (1993), Selden and Song (1993), and Suri and Chapman (1998). Similarly, as noted from the Kahuthu, (2006) change in terms of trade alters the composition of trade. Therefore, if the trading partners belong to different income levels, effect travels in the opposite direction. For example: if trade flows from developing country to a developed country, it increases emissions intensity in developing country but reduces in developed country. The study of Cole (2004) examines the trade-environment impact of OECD and non-OECD countries and validates this notion with ‘pollution haven hypotheses’. Managi et al., (2009) re-visited the trade-environment nexus for OECD and non-OECD countries using different estimation technique on two pollutants (SO_2 and CO_2) and found identical results to Cole (2004). The further contribution to trade environment literature considering changes in the EKC’s of countries with changing trade patterns is recently studied by Managi and Jena (2008), and Ahmed and Long (2013a). Thirdly, the quantitative techniques and methodology utilized for the analysis of trade and its environmental repercussions has a sufficient role in contradictory results. Therefore, while comparing the empirical results and cross-policy analysis of environmental consequence of trade openness, the methodological framework possesses important consideration (Suri and Chapman, 1998; Copeland and Taylor, 2003; Duro and Padilla, 2006; Pan et al., 2008; Hossain, 2011; Qazi et al., 2012; Shahbaz et al., 2013; Ahmed and Qazi, 2014; Ling et al., 2015). For example: the study of Grossman and Krueger (1991) used a random effects model to estimate the three pollutants and found SO_2 statistically significant. However, Seldon and Song (1994) conducted a similar study on four pollutants using cross-national panel data and found all four pollutant exhibits inverted-U shaped relationship. The later study of Suri and Chapman (1998) incorporates the actual movement of goods between industrializing and industrialized countries. Their study uses pooled cross-section time series data and reveals that manufacturing goods are imported from industrializing countries the curve moves downward and shows improving environmental conditions. Nevertheless, Birdsall and Wheeler (1994) using case study method on Latin America concluded that the protected economies favor emissions intensive industries. On pollution havens, Mani and Wheeler (1998) opine that the pollution havens are as transient as low wage havens, because the countervailing effects contribute to cleaner production through technical efficiency and tougher environmental regulations. Meanwhile, criticism on both growth-environment relationship and methodology continued simultaneously. A survey study of Dinda (2004) explains the progress of economic development in three stages. It starts with agrarian economy and attains pollution intensive industrial economy and then turns to clean service economy. Multivariate economic analyses of Cole et al., (2005) validate the analysis of Dinda (2004) and found developing countries as consistent pollution havens and hence contribute to dirty production. It is mainly because of FDI inflow from developed countries. Nevertheless, recent literature shows consistent results due to improved methodology and empirical techniques for single country analysis (Wacziarg and Welch, 2008; Jalil and Mahmud, 2009; Fodha and Zaghdoud, 2010; Peters et al., 2011; Sadorsky, 2012; Shahbaz et al., 2013;

Kawahara, 2014; Chang, 2015), but cross-country and panel data estimation require further investigation.

Keeping in view of the past literature, this study is uniquely designed while selecting the data set and methodological framework. The BICS countries are opted on the basis of income level, their profile in terms of trade volume, production and future emissions, and having similarity in economic structure. The literary debate on the relationship of trade openness and CO_2 emissions started with the advent of industrialization. The last three decades have witnessed the most proliferating period of trade openness. The world economy has grown at its fastest rate in human history. The fruits of globalization disseminated far and wide and many of the developing economies transformed into the development phase, and many are in the process. The future projections are quite healthy and global surge to eradicate poverty and boosting world economy uniformly provide confidence to such projections. However, this industrialization and globalization has come with certain cost and that cost is environmental health. Undoubtedly, the globalization has expanded the world trade in manifolds and contributed consecutive growth trend with smooth technology transfer, financial development, fast communication and ease of mobility of goods and services with geographical and comparative advantage amongst the economies. The world production has increased by 500% during the last thirty years. This production process becomes possible to the combustion of land and energy resources. Simultaneously the emissions of CO_2 in the earth's atmosphere is concentrated to such extend that its negative impacts are highly damaging and deteriorating to the eco-system. The frequent occurrence of natural disasters, disease breakout, and extinction of hundreds of living species has raised questions for researchers. However, the scholarly community of divided into two main schools of thought. Some support trade liberalization as the key source during last decades that helped million of people to come out of poverty and disseminate the growth fruits and equally distribution of resources. On the other hand, the environmentalists argue that globalization has taken us at that stage where we need to care global environment which is a global externality and re-shape the policies of trade with the compatibility of environmental friendly. This division is not just on the basis of theoretical background, but the research conducted on the relationship of trade openness and emissions trend has shown different and biased results. There are some studies which show that trade openness contribute to emissions and some does not. Some argue that the structure of the economy is much more important for the cause and effect of technical development and has been the central due to the opening of trade relationship (Topalova and Khandelwal, 2011; Copeland and Taylor, 2013; Shahbaz et al., 2013). Some argued that the methodology used to conduct such study also released biased results (Managi, 2009; Hossain, 2011; Ahmed and Long, 2013; Shahbaz et al. 2014; Ahmed et al. 2015; Qureshi et al., 2016). The single and multi-country analysis and regional studies have also shown different outcomes (Mazzanti et al. 2008; Lee et al. 2009; Hossain, 2011; Jalil and Faridun, 2011; Shahbaz et al., 2012).

Nevertheless, there is still wide gap persist in literature on trade-environment nexus discussed by Dinda, 2004 and later proceeded by Managi and Jena, 2008. The empirical investigations on trade-environment nexus are not sufficient is ample literature available on growth and the environment (e.g. Grossman and Krueger, 1991) debate during the since trade liberalization and contributes. Till today, trade liberalization has widely contributed in the mid of the twentieth century. With the opening of economies, it is commonly believed that trade benefited both for developed and developing countries and as a result, more countries are now moving towards liberal trade regimes to enhance their economic growth.

3. Model Construction and Data Collection

Economic growth, trade openness and energy consumption are widely used determinants of environmental quality. Environmental quality is a set of characteristics of air, noise and water pollution. Four types of indicators are commonly used to measure different pollutants: (i) emissions per capita, (ii) emissions per gross domestic product (pollution intensity), (iii) ambient levels of pollution (concentrations; impacts on a certain area) and (iv) total emissions. In panel data studies, the most frequently used indicator for pollution is CO_2 emissions per capita (see Arouri et al. 2012; Han and Lee, 2013; Omri, 2013; Gul et al., 2015). The present study uses CO_2 emissions per capita (C_{it}) to measure environmental pollution. Real GDP per capita (Y_{it}) is used to measure economic growth (US$). The indicator of trade openness (TR_{it}) is defined as export plus import divided by population, i.e. total volume of trade per capita (US$). Energy consumption in kg of oil equivalent per capita is used to measure energy consumption (E_{it}). All variables are in natural logarithm. The review of literature leads us to formulate following empirical model:

$$C_{it} = \alpha_1 + \alpha_2 Y_{it} + \alpha_3 TR_{it} + \alpha_4 E_{it} + \mu_i \qquad (1)$$

The BICS[8] countries are selected for the estimation of causality between CO_2 emissions and trade openness on the basis of data availability over the period of 1970-2013. All necessary data for the sample period are obtained from World development Indicators (CD- ROM, 2013).

3.1. Cross Sectional Dependence Tests

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[8] BICS group is comprises of 4 newly industrialized economies; Brazil, India, China and South Africa.

Trade liberalization insinuates interdependence of countries via import and export phenomena. Because the goods and services produced and traded in a well defined and systematic process, technically statistical analysis foresee the possibility unobserved common shocks in cross-sections of our panel. Later, these unobserved shocks become the integrated part of the residual and give inconsistent standard error (De Hoyos and Sarafidis, 2006; and Driscoll and Kraay, 1998). The cross-sectional dependence is tested by applying two different, but appropriate parametric tests proposed by Friedman (1937) and Pesaran (2007). The tests' specification is as follows:

Freidman's statistics compute:

$$R = \frac{2}{N(N-1)} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{r}_{ij} \qquad (2)$$

Where $\hat{r}$ is the spearman's rank correlation coefficient

$$r_{ij} = r_{ji} = \frac{\sum_{t=1}^{T} \left(r_{it} - \left(T + 1/2\right)\right)\left(r_{jt} - \left(T + 1/2\right)\right)}{\sum_{t=1}^{T} \left(r_{it} - \left(T + 1/2\right)\right)^{2}}$$ of the residuals.

Pesaran's statistics compute:

$$CD = \sqrt{\frac{2T}{N(N-1)}} \left(\sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij} \right) \qquad (2)$$

Where $\hat{\rho}_{ij}$ is the estimate of;

$$\rho_{ij} = \rho_{ji} = \frac{\sum_{t=1}^{T} \varepsilon_{it}\varepsilon_{jt}}{\left(\sum_{t=1}^{T} \varepsilon_{it}^{2}\right)^{1/2} \left(\sum_{t=1}^{T} \varepsilon_{jt}^{2}\right)^{1/2}} \quad (3)$$

The null hypothesis to be tested as: $\rho_{ij} = \rho_{ji} = corr(\varepsilon_{it}, \varepsilon_{jt}) = 0$ for i ≠ j and the alternative hypothesis to be tested is $\rho_{ij} = \rho_{ji} \neq 0$ for some i ≠ j.

3.2. Panel unit root tests

This study applies cointegration test to see the long-run association among all underlying vectors (i.e. CO_2 emissions, trade openness, energy consumption and economic growth) on time series data. Time series data require unit root tests of all the variables to ensure that the variables are non-stationary. Therefore, it is now a standard approach in time series analysis to apply unit root test prior to cointegration test. There are number of unit root tests proposed by Levin and Lin, 1993; Hansen, 1995; Im, Pesaran and Shin, 1997; Madala and Wu, 1999; and Levin et al., 2002). We utilize panel covariate-augmented Dickey Fuller (*p* CADF) test for unit root originally developed in Hansen (1995), and not to be confused with Pesaran, (2007). The Pesaran's test explicitly addresses the problem of cross-sectional dependence. The *p-CADF* is further generalizing for individual unit root testing and applicable even in the presence of cross-section dependence (Hartung, 1999) due to asymptotic used and does not require N→∞ (Choi, 2001). Hence, this approach is easily computable, allows power gain, possesses better size properties than other unit root tests and suits macroeconomic data (Costantini and Lupi, 2013).

3.3. Panel Cointegration Tests

Once the panel unit root tests confirm that the time series data is non-stationary, we now proceed to panel cointegration test. There are two types of approaches used for cointegration, one tests the underlying vectors on the basis of the null hypothesis of "cointegration" (McCoskey and Kao, 1998; Westerlund, 2007) and other takes the null hypothesis of "no-cointegration" (Pedroni, 1999; Kao, 1999; Larsson et al., 2001; Groen and Kleibergen, 2003). We utilize Pedroni panel cointegration test proposed by Pedroni (1999, 2004). Pedroni's test proposes seven different statistics to test for cointegration relationship in heterogeneous panel. These tests are corrected for bias introduced by potentially endogenous regressors. The seven test statistics of Pedroni are classified into within the dimension and between dimensions statistics. Within dimension statistics are referred to as panel cointegration statistics, while between dimension statistics are called group mean panel cointegration statistics. These cointegration test statistics are based on the extension of two step residual based strategies of Engle and Granger (1987). The procedure involves the estimation of seven test statistics require in the first step to estimate the following panel cointegration regression and store the residuals:

$$x_{i,t} = \alpha_{0i} + \rho_i t + \beta_{1i} Z_{1i,t} + ... + \beta_{mi} Z_{mi,t} + \mu_{it} \qquad (4)$$

In the second step, take the first difference of original data series of each country and compute the residual of differenced regression:

$$\Delta x_{i,t} = \theta_{1i} \Delta Z_{1i,t} + ... + \theta_{mi} \Delta Z_{mi,t} + \eta_{it} \qquad (5)$$

In the third step, estimate the long-run variance ($\hat{\kappa}^2_{11,i}$) from the residuals ($\hat{\eta}_{it}$) of the differenced regression. In the fourth step, using the residual ($\hat{\mu}_{it}$) of the original co integrating equation, estimate the appropriate autoregressive model. Following these steps, the seven panel statistics are then computed with appropriate mean and variance adjustment terms as described by Pedroni (1999).

Panel v-Statistic:

$$Z_v \equiv T^2 N^{3/2} \left(\sum_{i=1}^{N} \sum_{t=1}^{T} \hat{\kappa}_{11,i}^{-2} \hat{\mu}_{it-1}^{2} \right)^{-1} \qquad (6)$$

Panel ρ -statistic:

$$Z_p \equiv T\sqrt{N} \left(\sum_{i=1}^{N} \sum_{t=1}^{T} \hat{\kappa}_{11,i}^{-2} \hat{\mu}_{it-1}^{2} \right)^{-1} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{\kappa}_{11,i}^{-2} \left(\hat{\mu}_{it-1} \Delta \hat{\mu}_{it} - \hat{\lambda}_i \right) \qquad (7)$$

Panel t-statistic (non-parametric):

$$Z_t \equiv \left(\tilde{\sigma}^2 \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{\kappa}_{11,i}^{-2} \hat{\mu}_{it-1}^{2} \right)^{-1/2} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{\kappa}_{11,i}^{-2} \left(\hat{\mu}_{it-1} \Delta \hat{\mu}_{it} - \hat{\lambda}_i \right) \qquad (8)$$

Panel t-statistic (parametric):

$$Z^*{}_t \equiv \left(\tilde{s}_{N,T}^{*2} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{\kappa}_{11,i}^{-2} \hat{\mu}_{it-1}^{2} \right)^{-1/2} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{\kappa}_{11,i}^{-2} \hat{\mu}_{it-1}^{*} \Delta \hat{\mu}_{it}^{*} \qquad (9)$$

Group ρ-statistic:

$$\tilde{Z}_p \equiv T N^{-1/2} \sum_{i=1}^{N} \left(\sum_{t=1}^{T} \hat{\mu}_{it-1}^{2} \right)^{-1} \sum_{t=1}^{T} \left(\hat{\mu}_{it-1} \Delta \hat{\mu}_{it} - \hat{\lambda}_i \right) \quad (10)$$

Group t-statistic (non-parametric):

$$\tilde{Z}_t \equiv N^{-1/2}\sum_{i=1}^{N}\left(\hat{\sigma}_i^2\sum_{t=1}^{T}\hat{\mu}_{it-1}^2\right)^{-1/2}\sum_{t=1}^{T}\left(\hat{\mu}_{it-1}\Delta\hat{\mu}_{it}-\hat{\lambda}_i\right) \qquad (11)$$

Group t-statistic (parametric):

$$\tilde{Z}_t^* \equiv N^{-1/2}\sum_{i=1}^{N}\left(\sum_{t=1}^{T}\tilde{s}^{*^2}\hat{\mu}_{it-1}^{2*}\right)^{-1/2}\sum_{t=1}^{N}\hat{\mu}_{it-1}^{*}\Delta\hat{\mu}_{it}^{\;*} \qquad (12)$$

Where $\hat{\lambda}_i = \frac{1}{2}(\hat{\sigma}_i^2 - \hat{s}_i^2)$ and $\tilde{s}_{N,T}^{*^2} = \frac{1}{N}\sum_{i=1}^{N}\hat{s}^{*^2}$ (13)

After the calculation of the panel cointegration test statistics the appropriate mean and variance adjustment terms are applied, so that the test statistics are asymptotically standard normally distributed.

$$\frac{X_{N,T} - \mu\sqrt{N}}{\sqrt{V}} \Rightarrow N(0,1) \qquad (14)$$

Where $X_{N,T}$ is the standardized form of test statistics with respect N and T. u and v are the functions of moment of the underlying Brownian motion functional. All statistics test the null hypothesis of no cointegration as:

$$H_0 : \rho_i = 1 \quad for\ all\ i = 1, 2, ..., N \qquad (15)$$

Alternative hypothesis for between dimension and within dimension for panel co integration is different. The alternative hypothesis for between dimension statistics is as follows:

$$H_0 : \rho_i < 1 \quad for\ all\ i = 1, 2, ..., N \quad (16)$$

Where a common value for $\rho_i = \rho$ is not required. The alternative hypothesis for within dimension based statistics is given below:

$$H_0 : \rho_i = \rho < 1 \quad for\ all\ i = 1, 2, ..., N \qquad (17)$$

Assume a common value for $\rho_i = \rho$. Under the alternative hypothesis, all the panel test statistics diverge to negative infinity. Thus, the left tail of the standard normal distribution is required to reject the null hypothesis.

3.4. Panel Cointegration Estimates

When all the variables are cointegrated, the next step is to estimate the associated long-run cointegration parameters. Fixed effect, random effect and GMM method could lead to inconsistent and misleading coefficients when applied to cointegrated panel data. For this reason, we estimate the long-run models using the FMOLS (fully modified OLS) methods. Following Pedroni (2001), FMOLS technique generates consistent estimates in small samples and does not suffer from large size distortions in the presence of endogeneity and heterogeneous dynamics. The panel FMOLS estimator for the coefficient β is defined as:

$$\hat{\beta} = N^{-1}\sum_{i=1}^{N}\left(\sum_{t=1}^{T}(y_{it}-\overline{y})^2\right)^{-1}\left(\sum_{t=1}^{T}(y_{it}-\overline{y})\right)z_{it}^{*} - T\hat{\eta}_i \quad (18)$$

Where $z_{it}^{*} = (z_{it}-\overline{z}) - \frac{\hat{L}_{21i}}{\hat{L}_{22i}}\Delta y_{it}$, $\hat{\eta}_i \equiv \hat{\Gamma}_{21i} + \hat{\Omega}_{21i}^{0} - \frac{\hat{L}_{21i}}{\hat{L}_{22i}}(\hat{\Gamma}_{22i} + \hat{\Omega}_{22i}^{0})$ and $\hat{L}_i$ is a lower triangular decomposition of $\hat{\Omega}_i$. The associated t-statistics gives:

$$t_{\hat{\beta}^*} = N^{-1/2}\sum_{i=1}^{N} t_{\hat{\beta}^*,i} \quad \text{Where} \quad t_{\hat{\beta}^*,i} = \left(\hat{\beta}_i^{*} - \beta_0\right)\left[\hat{\Omega}_{11i}^{-1}\sum_{t=1}^{T}(y_{it}-\overline{y})^2\right]^{1/2} \quad (25)$$

3.5. Panel Causality Test

The work of Granger, (1969) developed an econometric model that investigates the causal relationship among the variables, based on cross-spectral method. Following the similar method, we analyse the causal relationship between trade openness, CO_2 emissions, economic growth and energy consumption. We opt bilateral (pairwise) Granger causality teats for heterogeneous panels instead of the VECM Granger causality approach developed in Engle and Granger (1987), because the vectors are already passed through unit-root and cointegration tests that ensure the time series is non-stationary and cointegration. Eq. 26-27 tests the bilateral causal relationship between trade openness and CO_2 emission, and similar expression can be rewritten for each pair of variables as mentioned in Table 5:

$$C_{it} = \alpha_i + \sum_{j=1}^{K}\alpha_{11ij}^{(j)}C_{i,t-j} + \sum_{j=1}^{K}\alpha_{12ij}^{(j)}T_{i,t-j} + \varepsilon_{it} \quad (26)$$

$$T_{it} = \alpha_i + \sum_{j=1}^{K}\alpha_{11ij}^{(j)}T_{i,t-j} + \sum_{j=1}^{K}\alpha_{12ij}^{(j)}C_{i,t-j} + \varepsilon_{it} \quad (27)$$

Where α_i are constant throughout the time dimension, K denotes uniform lag orders for all cross-sections of the panel. We allow $\alpha_{11ij}^{(j)}$ as an autoregressive parameter and $\alpha_{12ij}^{(j)}$ is coefficient of slope to vary across the groups. The model is fixed coefficient model and uses fixed individual effect as in Dumitrescu and Hurlin, (2012). The bilateral Granger causality with lag lenth (SIC=2) is applied to test the direction of causality between the variables. We test the heterogeneous no-causality hypothesis (under the null hypotheses ($H_0 : \alpha_{12ij} = 0 \;\; \forall_{12ij} = 1, ..N$). The value of F-statistics and p-value signify whether to reject or not to reject the null hypothesis, reports the existence or no causality, respectively.

4. Results and Discussion

This section interprets the results of empirical analysis and discusses their policy implication in context to the panel countries (i.e. Brazil, India, China, South Africa). The literature on panel data suggest that the panel data set may possesses the cross-sectional dependenec (De Hoyos and Sarafidis, 2006) that oversees the common shocks (Chang, 2002) and ultimately become the part of residual and leads to biased standard error values (Hoechle, 2007). Therefore, in order to ensure the robustness of standard error in our panel data estimation, this study uses two cross-sectional indepenndence tests developed by Friedman (1937) and Pesaran (2007). Table 1., demonstrates the results of cross-sectional independence tests of Friedman and Pesaran for all variables. The probability values in parenthesis show that the null of cross-sectional independence is rejected and it spells that the variables are cross-sectionally independent and the panel data set is statistically significant for empirical tests.

Table-1 paste here

The time series econometrics necessiatate that the underlying series must be stationary and should not carry unit root otherwise it produces spurious regression (Phillips 1987; Johansen, 1988). It is now common pratice in time series econometrics to check the underlying vector for unit root (Gujrati, 2012; Wooldridge, 2012; Granger and Newbold, 2014). Hence, the variables are tested for panel unit root analysis to see whether all the underlying series are stationary or not. Table 2., reports the results of both LLC and CADF panel unit root tests. We find that all the variables are found non-stationary at level excepty economic growth which is stationary at 10% level of significance in CADF unit root test. However, After first differencing, CO_2 emissions, economic growth, trade openess and energy consumption are stationary in both panel LLC and CADF unit roots. It further indicates that all the variables have unique order of integration and ready for cointegration analysis.

Table-2 paste here

We have applied the Pedroni (1999, 2004) approch to cointgeration to investigate the long-run relationship between the variables. The Pedroni approach to panel cointegration test is residual-based tests approach In total, seven test statistics are provided in Pedroni panel cointegration test and these are further divided into two categories; four within dimension panel test statistics and three between dimension group statistics to check whether the variables in panel data are cointegrated. The within dimension tests are based on the estimators that pool the autoregressive coefficients across the countries (cross-sections) for the unit root test on the residual (Pedroni, 1999). The between dimension tests are less restrictive and allow parametric heterogeneity across the cross-sections (Sadorsky, 2011). Table 3., shows the panel cointegration test. The results of within dimension and between dimension tests allow us to reject the null hypothesis of "no-cointegration" and confirm that CO_2 emissions, economic growth, energy consumption and trade openness are cointegrated in most of the cases. It means CO_2 emissions, economic growth, trade openness and energy consumption are cointegrated and have long-run association in case of BICS.

Table-3 paste here

Subsequent to Pedroni panel cointegration test, and confirming the cointegration among all underlying vectors, the long-run elasticity between CO_2 emissions and trade liberalization, economic growth and energy consumption is determined using panel-FMOLS test. This is a new method and has a property to estimate and test the hypothesis for cointegrating vectors in dynamic panels while being consistent with the available degree of cross-sectional heterogeneity recently allowed in unit root and panel cointegration studies (Pedroni, 2001& 2007; Breitung, 2005; Liddle, 2012). The results of the panel-FMOLS are reported in Table 4, and suggest that trade and GDP has negative and statistically significany effect on CO_2 emission, where in long-run, a 1% increase in trade openness and economic growth reduce CO_2 emissions by 0.54% and 0.39%, respectively However, energy consumption has positive and statistically significant effect on CO_2 emission. The Panel FMOLS test results further entails that due to technology and income effect of trade and GDP growth in long-run improves the environmental quality in Brazil, India, China and South Africa by reducing the CO_2 emission. But, countries need to revisit the national policy to achieve energy efficiency and susbstantial inclusion of renewables to avoid adverse environmental consequence of energy consumption in long-run.

Table-4 paste here

Table 5., shows the result of the Granger causality test; we found that the bi-directional causality running between energy consumption and CO_2 emissions. It implies that the energy utilized in production processes is highly emission intensive and higher production leads energy consumption and CO_2 emissions to excite each other. The unidirectional causality exists running from trade openness and economic growth to CO_2 emissions. Trade openness Granger causes energy consumption. The unidirectional causality is found running from trade openness to economic growth. It means the economic growth in Brazil, India, China and South Africa mainly drive by export-led growth policy. As manufacturing sector dominates export sector, heavily rely on fossil fuels and includes less energy efficient techlogy; hence, it significantly contributes to CO_2 emission. However, the recent literature argues that Granger causality test analyzes the causal relationship between the variables, but it does not tell us the ratio of contributions Shahbaz (2012). However, the variance decomposition approach and impulse response function calculate the relative strength of causal link between the variables in a decomposed form. Hence, forecast error variance decomposition method (FEVDM) along with the impulse response function (IRF) test provides Innovative Accounting Approach (IAA) to determine the causal relationship among the variables. During the decomposition analysis, the exact ratio of each exogenous variable over the endogenous variable is computed at different time horizons during their own innovative shocks.

Table-5 paste here

Similarly, we utilized IAA to test the causal links between CO_2 emissions, economic growth, energy consumption and trade openess in BICS. The results suggest, during its own innovative shocks, energy consumption is 67.3% self contributed and 21.4% is contributed by trade openness. It implies that the energy demand in BICS is mainly driven by trade openness. CO_2 emissions is 33.4% self contributed and, 52.4% and 11.3% is contributed by energy consumption and trade openness, respectively. It suggests that energy consumption and trade openness are the two major exogenous factors highly contribute to CO_2emissions in BICS. Trade openess cause energy consumption and CO_2 emission, energy consumption further leads to CO_2 emission and energy cosnumption feedback trade openness. Trade openness is 94.2% self contributed and does not receive a substantial impact from the rest of the variables. However, economic growth is 44.0% self contributed and 21.0%, 20.8% and 14.0% exogenously contributed by trade openness, energy consumption and CO_2 emissions, respectively. It means that the economic growth in BICS countries is substantially depeneds on trade openess and energy consumption and overall higher economic growth cause higher environmental damage through CO_2 emissions. The overall VDM test results suggest that economic growth in BICS countries is highly energy and emission intensive. There is need to revisit the industrial policy to counter the negative enviroenmental impacts of production side. The increasing environmental damage may limit the fruits of higher economic growth, hence BICS countries are at the crossroads where they have to trade off between sustainable economic growth and environment degradation. The VDM test results are further checked for impulse response function (IRF) test and Fig. 4 displays the pairwise impact of variables during the period of shocks. The IRF is used as an alternate to VDM test, but shows the graphical representation of reaction of variables throughout the period. We note that forecast error arising in energy consumption, trade openness and economic growth has a positive contribution to CO_2 emissions. Trade openness and economic growth contribute to energy consumption positively. Energy consumption responds positively due to forecast error occurs in CO_2 emissions. Trade openness and energy consumption, stimulate economic growth by their forecast errors.

Table-6 paste here

Fig-4 paste here

5. Conclusion and Policy Implications

This study empirically examines the impact of trade openness on CO_2 emissions with energy consumption and economic growth for four newly industrializing economies, i.e. China, India, Brail, and South Africa. We employed a cross-sectional independence test prior to panel unit root test. After confirming the variables are integrated at I (1) and cross-sectionally independent, we applied dynamic panel cointegration test developed in Pedroni (2001, 2007). The results found that the majority of the variables are cointegrating and confirm the long-run association between CO_2 emissions, economic growth, energy consumption and trade openess. Furthermore, the long-run elasticity between the variables is checked using Fully Modified OLS test followed by Granger causality and forecast error variance decompostion (FEVDM) test for causality and decompostion analysis, respectively. The overall results conclude that the trade liberalization significantly contribute to economic growth with increased gross domestic output, butthe production is both energy and emission intensive. The study of Copeland and Taylor (1994) and Tsurumi and Managi (2010) highlights such situation when scale effect dominates technique and composition effect due to weak infrastructure and technology, where higher economic growth reduces enviroenmental quality and raises future environmental and energy security concerns in the countries.

The results of this study possesses deep policy implications for China, India, Brazil and South Africa. Today, the share of these industrializing economies is one-fifth of the world GDP, 35% of global energy use, and 40% of global CO_2 emissions. Granger causality analysis suggests that there is the unidirectional causality running from trade openness to economic growth and carbon emissions. It means trade liberalization is good for economic growth, but also induces CO_2 emissions. However, there is also the feedback effect between energy consumption and CO_2 emissions. It further clarifies that trade openness enhances energy use in the economies due to the increased scale of production and deteriorates environmental quality. As a matter of fact, it is not feasible for economy to reduce its production in order to consume less energy and in return gets better environment and deteriorating economic growth. The absence of causality between energy consumption and economic growth suggests that energy conservation policies will not affect economic growth in the newly industrialized countries. This study also suggests that the newly industrializing economies should adopt renewable and alternate energy sources to reduce the emissions intensity of production units without compromising economic growth.

The long-run analysis results of FMOLS test suggests that trade liberalization offsets its impact in the shape of the lesser emission intensive production. It sounds the existence of the EKC hypothesis for these countries. However, as a policy implication, our study suggests that the adoption of new CDM[9] projects by relocating firms from technologically developed countries

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[9] Clean Clean development mechanism (SDM) and Joint implementation (JI) are designed under Kyoto Protocol as emission reduction strategy through international technology diffusion from industrialized to industrializing

would help to reduce emission intensity of production units in the newly industrialized economies through international technology diffusion. Now, as far as energy consumption is concerened, Brazil, India, China and South African economies project higher energy demand for their sustainable economic growth, but such demand carries environmental concerns both in short- and long-run paths. Our findings offer two key policy implications in this regard. First, there is a need to revisit the environmental and industrial policy and then integrating the both for cleaner output. For example: the export led growth policy is the key driver of gross domestic output in BICS' economies; therefore, it entails certain sustainable development policy structure which does not comprise the industrial scale. Secondly, the countries are required to invest sufficiently in energy efficient technology and renewable energy sources. It does not only solve their rising energy security problem but also help them to achieve sustainable energy and environmental goals.

In addition, our study further puts up an interesting question that what sort of output and long-run economic growth required for sustainable development of BICS countries. Because if BICS countries tend to produce output with continuing and excessive use of fossil energy, no doubt it produces higher output but at the cost of environmental quality in these economies. Thus, the environmental degradation due to fossil fuel energy consumption beyond threshold will definitely deny environmentally sustainable economic growth in BICS countries. This again puts a serious concern before the governments and fiscal policy makers in BICS countries to think of adopting the energy efficient technologies with susbstantial inclusion of renewable energy sources in their production processes. It may ensure higher production put put with reduced

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countries. for more insights regarding SDM and JI please refer: Youngman et al.,(2007); Dechezleprêtre et al., (2008); Ahmed and Long, (2013b).

enviroenmental cost. Hence, BICS economies have to design such a policy which does not only ensures sustainable economic growth but also reduces enviroement damage.

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Tables:

Table 1. Cross-sectional Independence Tests

Test Statistics	Friedman	Pesaran	ABS*
$\ln C_{it}$	0.19 (0.842)	28.21(0.000)	0.615
$\ln Y_{it}$	0.21 (0.680)	5.00 (0.000)	0.386
$\ln T_{it}$	13.65 (0.000)	-1.28 (0.202)	0.805
$\ln EC_{it}$	0.19 (0.842)	28.21(0.000)	0.671

Note: P-values are in parentheses.

(*)ABS is the average absolute value of the off-diagonal elements of the residuals.

Table 2. Panel Unit Root Analysis

Variables	**At level**				**At 1st Difference**			
	Constant	P-value	Constant and Trend	P-value	Constant	P-value	Constant and Trend	P-value
LLC Unit Root Test on Demeaned Series								
$\ln C_{it}$	3.8546	0.1916	0.7189	0.9181	-5.0100*	0.0000	-6.3768*	0.0000
$\ln Y_{it}$	4.0052	1.0000	0.0115	0.5046	-5.1540*	0.0000	-5.1302*	0.0000
$\ln T_{it}$	2.8043	0.9975	-1.1562	0.1238	-6.7009*	0.0000	-6.9385*	0.0000
$\ln EC_{it}$	3.6933	0.9030	1.2898	0.9030	-4.3763*	0.0000	-4.2742*	0.0000
CADF Unit Root Test								
$\ln C_{it}$	4.8729	1.2356	-3.4567	0.3750	-3.6541*	0.0045	-3.8237*	0.0038
$\ln Y_{it}$	3.3248	0.8272	-3.0601	0.0904	-3.0609*	0.0098	-4.1723*	0.0023
$\ln T_{it}$	3.7484	1.2638	-3.5262	0.2941	-3.5262*	0.0011	-3.8270*	0.0023

$\ln EC_{it}$	3.5678	0.2237	-3.0609	0.8873	-3.0607*	0.0275	-3.8734*	0.0763
Note: * shows significant at 1% level.								

Table 3. Pedroni Panel Cointegration Test Results

<table>
<tr><td colspan="5">Alternative hypothesis: common AR coefs. (within-dimension)</td></tr>
<tr><td>Tests</td><td>Statistics</td><td>P-value</td><td>Weighted Statistics</td><td>P-value</td></tr>
<tr><td>Panel υ-statistic</td><td>2.373081</td><td>0.0088</td><td>1.137388</td><td>0.1277</td></tr>
<tr><td>Panel σ-statistic</td><td>-2.872699</td><td>0.0020</td><td>-1.389854</td><td>0.0823</td></tr>
<tr><td>Panel ρρ-statistic</td><td>-3.045199</td><td>0.0012</td><td>-2.014688</td><td>0.0220</td></tr>
<tr><td>Panel adf-statistic</td><td>2.373081</td><td>0.0088</td><td>1.137388</td><td>0.0197</td></tr>
<tr><td colspan="5">Alternative hypothesis: individual AR coefs. (between-dimension)</td></tr>
<tr><td>Tests</td><td colspan="2">Statistics</td><td colspan="2">P-value</td></tr>
<tr><td>Group σ-statistic</td><td colspan="2">1.446330</td><td colspan="2">0.1402</td></tr>
<tr><td>Group ρρ-statistic</td><td colspan="2">-0.831221</td><td colspan="2">0.2824</td></tr>
<tr><td>Group adf-statistic</td><td colspan="2">-2.003168</td><td colspan="2">0.0536</td></tr>
</table>

Null Hypothesis: No cointegration

Trend assumption: No deterministic trend

Automatic lag length selection based on SIC with a max lag of 9

Newey-West automatic bandwidth selection and Bartlett kernel

Table 4. FMOLS Panel Results

(lnC_{it}): Dependent Variable		
Variables	Coefficient	P-value
$\ln Y_{it}$	-0.398	0.0003
$\ln T_{it}$	-0.542	0.0264
$\ln EC_{it}$	0.365	0.0000

Table 5. Granger Causality Test Results

Granger Causality Test				
Null Hypothesis (H_0):	Results	Direction	F-Stat.	Prob.
EC does not Granger Cause C	Reject	EC→C	7.7840	0.0006
C does not Granger Cause EC	Reject	C→EC	3.8159	0.0241
T does not Granger Cause C	Reject	T→C	7.2610	0.0010
C does not Granger Cause T	Do not-Reject	-	2.0833	0.1279
Y does not Granger Cause C	Reject	Y→C	8.1950	0.0004

C does not Granger Cause Y	Do not-Reject	-	0.1075	0.8981
T does not Granger Cause EC	Reject	T→EC	10.411	6.E-05
EC does not Granger Cause T	Do not-Reject	-	1.9587	0.1444
Y does not Granger Cause EC	Do not-Reject	-	2.1802	0.1164
EC does not Granger Cause Y	Do not-Reject	-	0.0245	0.9758
Y does not Granger Cause T	Do not-Reject	-	1.7644	0.1746
T does not Granger Cause Y	Reject	T→Y	8.1159	0.0004

Note: (i) Arrow(→) shows the direction of causality.(ii) Lag-lenth (SIC=2). (iii)

Table 6. Variance decomposition analysis.

<table>
<tr><td colspan="5">Variance Decomposition of EC:</td></tr>
<tr><td>Period</td><td>EC</td><td>C</td><td>T</td><td>Y</td></tr>
<tr><td>1</td><td>100.0000</td><td>0.0000</td><td>0.0000</td><td>0.0000</td></tr>
<tr><td>3</td><td>95.9593</td><td>2.1407</td><td>0.3020</td><td>1.5978</td></tr>
<tr><td>5</td><td>92.5842</td><td>3.0956</td><td>1.3025</td><td>3.0176</td></tr>
<tr><td>7</td><td>88.7947</td><td>3.9723</td><td>3.1431</td><td>4.0897</td></tr>
<tr><td>9</td><td>84.4181</td><td>4.7259</td><td>5.9924</td><td>4.8634</td></tr>
<tr><td>11</td><td>79.3799</td><td>5.3046</td><td>9.9806</td><td>5.3347</td></tr>
<tr><td>13</td><td>73.6618</td><td>5.6785</td><td>15.1583</td><td>5.5011</td></tr>
<tr><td>15</td><td>67.3247</td><td>5.8389</td><td>21.4558</td><td>5.3804</td></tr>
<tr><td colspan="5">Variance Decomposition of C</td></tr>
<tr><td>Period</td><td>EC</td><td>C</td><td>T</td><td>Y</td></tr>
<tr><td>1</td><td>45.0508</td><td>54.9491</td><td>0.0000</td><td>0.0000</td></tr>
<tr><td>3</td><td>56.9775</td><td>41.3055</td><td>0.0973</td><td>1.6195</td></tr>
</table>

5	58.1682	38.9175	0.5067	2.4074
7	57.9781	37.9122	1.3303	2.7793
9	57.2477	37.1069	2.6909	2.9543
11	56.0984	36.1740	4.7272	3.0002
13	54.5091	34.9701	7.5772	2.9435
15	52.4278	33.4183	11.3547	2.7991
Variance Decomposition of T				
Period	EC	C	T	Y
1	1.1881	0.0942	98.7176	0.0000
3	4.3870	0.1602	95.4490	0.0036
5	4.9684	0.2071	94.8221	0.0022
7	5.1332	0.2754	94.5854	0.0058
9	5.1607	0.3573	94.4665	0.0153
11	5.1320	0.4476	94.3902	0.0299
13	5.0794	0.5426	94.3294	0.0484
15	5.0179	0.6392	94.2731	0.0695
Variance Decomposition of Y				
Period	EC	C	T	Y
1	18.8856	4.2825	0.5571	76.2747
3	16.8934	6.9356	1.3946	74.7763
5	17.8273	9.1920	2.6023	70.3782
7	19.0141	11.1011	4.4140	65.4707
9	20.0205	12.5998	7.0103	60.3691

11	20.7236	13.6179	10.551	55.1073
13	21.0698	14.1047	15.152	49.6732
15	21.0325	14.0400	20.849	44.0778

Figures:

Fig. 1. BICS Merchandise Trade (Bn. US$) - (1970-2013)

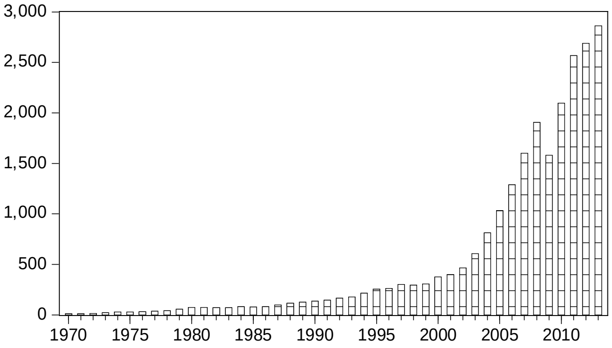
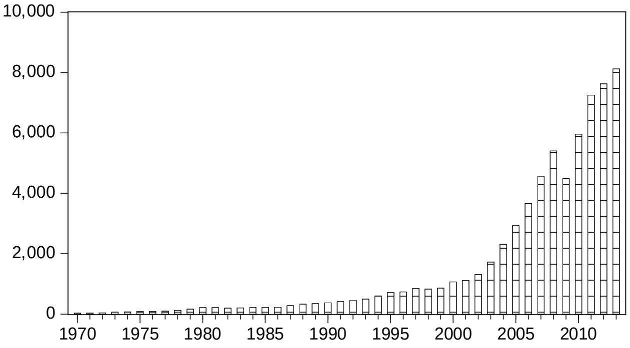
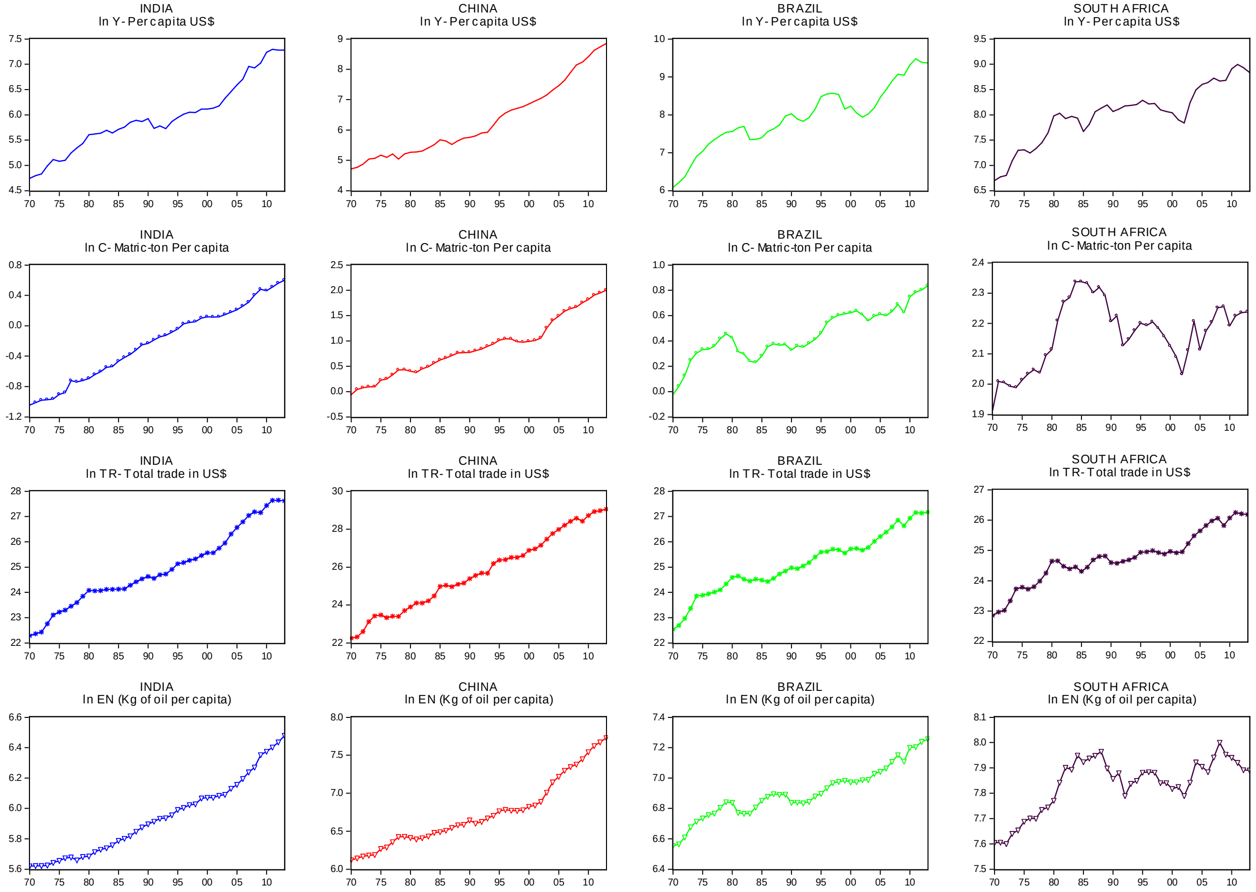


Fig. 2. BICS CO2 Emission (Mn. Mt. tons) - (1970-2013)



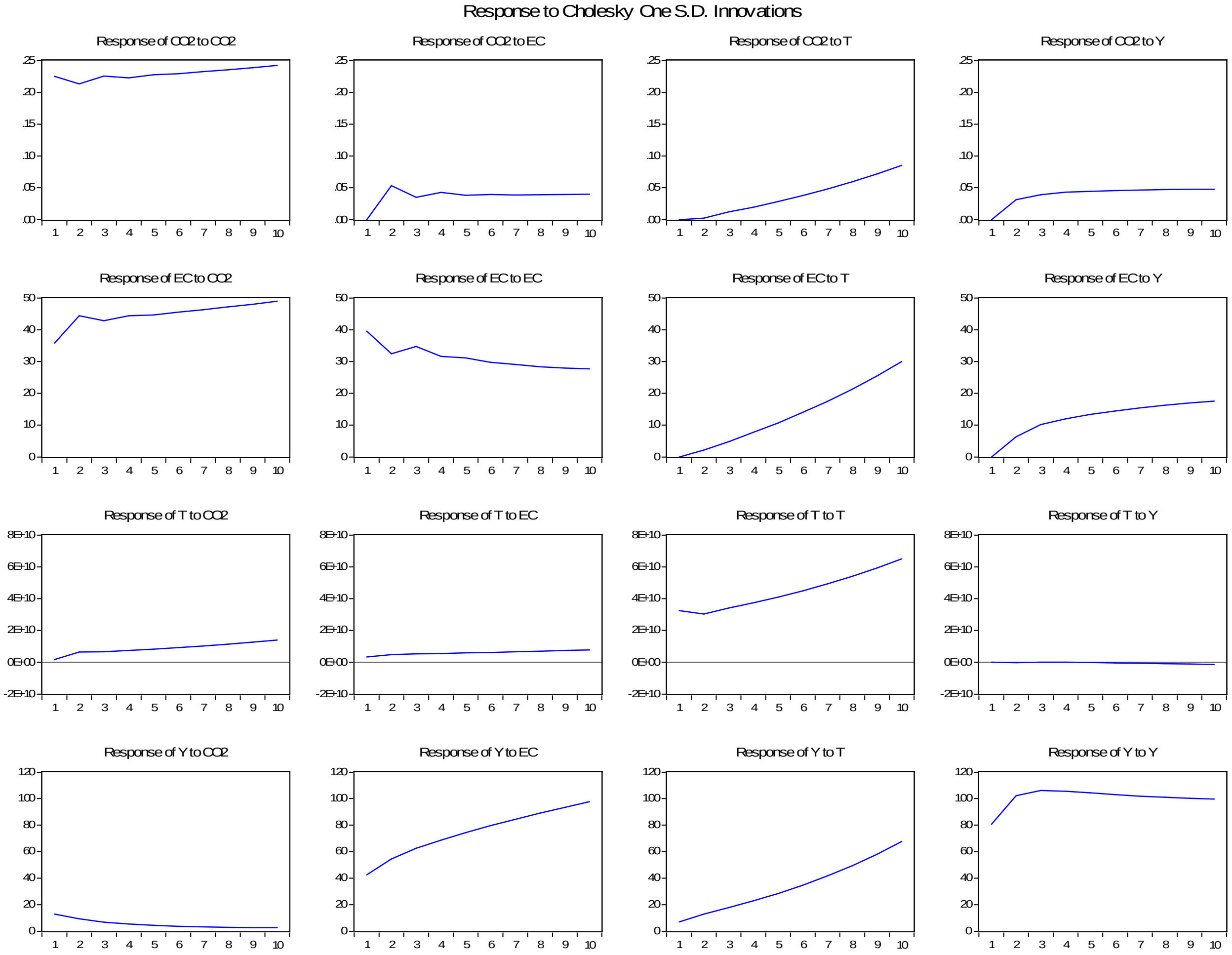
Source: World Bank, WDI-2014

Fig. 3. Trend in the variables



Sourse: World Development Indicators, 2014

Fig-4 Impulse response function



Response to Cholesky One S.D. Innovations

Response of CO2 to CO2

Response of CO2 to EC

Response of CO2 to T

Response of CO2 to Y

Response of EC to CO2

Response of EC to EC

Response of EC to T

Response of EC to Y

Response of T to CO2

Response of T to EC

Response of T to T

Response of T to Y

Response of Y to CO2

Response of Y to EC

Response of Y to T

Response of Y to Y