



Munich Personal RePEc Archive

Atmospheric consequences of trade and human development: A case of BRIC countries

Sinha, Avik and Sen, Sudipta

Accendere Knowledge Management Services, Indian Institute of Management Indore

2016

Online at <https://mpra.ub.uni-muenchen.de/100011/>
MPRA Paper No. 100011, posted 03 May 2020 14:42 UTC

1 **Atmospheric consequences of trade and human development: A case of BRIC countries**

2
3 Avik Sinha¹

4 Research Mentor, Accendere Knowledge Management Services

5 Ph: +91-97133 40444. Email: f11aviks@iimidr.ac.in

6
7 Sudipta Sen

8 Fellow Programme in Management (Economics), Indian Institute of Management Indore

9 Ph: +91-94251 25344. Email: f12sudiptas@iimidr.ac.in

10 **Abstract:**

11 This paper looks into the causal association between economic growth, CO₂ emission, trade
12 volume, and human development indicator for Brazil, Russia, India, and China (BRIC countries)
13 during 1980-2013. Following a generalized method of moments (GMM) technique, we have
14 found out that bidirectional causality exists between CO₂ emissions and economic growth.
15 Feedback hypothesis is supported between CO₂ emissions and human development, trade
16 volume and human development, economic growth, and human development, and CO₂ emissions
17 and trade volume. Apart from finding out the unidirectional association from trade volume to
18 economic growth, this study also validated the existence of Environmental Kuznets curve.
19 Empirical findings of the study substantiate that the policymakers of the BRIC nations must
20 focus on the green energy initiatives, either by in-house development or by technology transfer.
21 This movement will allow them to control the ambient air pollutions prevalent in these nations.

22 *Keywords:* economic growth; CO₂; trade; human development indicator; BRIC; GMM

23

¹ Corresponding Author

1 **1. Introduction**

2 Global warming and climate change is one of the major concerns worldwide. The Kyoto
3 Protocol was signed with the objective to minimize the damage of global warming and climate
4 change by taking steps to reduce greenhouse gases (GHG) emissions. Although the BRIC
5 countries signed the Kyoto Protocol, environmental concerns still remain due to their growth
6 potential (Pao and Tsai, 2010). The World Bank data on CO₂ emission shows that BRIC
7 countries emissions increased for these economies for the period from 2011-2015, with Brazil
8 growing at 1.15%, Russia 12.6%, India 1.7% and China 6.7% (World Bank, 2015). These four
9 countries, with a combined population of 3 billion people and a GDP of \$16tn, will have a huge
10 direct impact on global emissions.

11 The last few decades has seen several empirical studies connecting trade openness,
12 environmental conditions and human development (Ehrlich and Lui, 1991; Ekins, 1997; Pao and
13 Tsai, 2010; Pao and Tsai, 2011). However, very few studies were done in the context of BRIC
14 economies (Belloumi, 2009; Zhang and Cheng, 2009). Considering the causal associations,
15 Zhang and Cheng (2009) designed one of the earliest multivariate models, and the latest work is
16 carried out by Omri et al. (2015). These studies focused on establishing possible causal
17 associations between energy consumption, economic growth, and carbon emission by using
18 multivariate models, and these models assume the economic structure to be four-sector
19 (Mahalanobis, 1955), where the social determinants of economic growth and environmental
20 degradation have been ignored. Moreover, all of the studies show that the relationship between
21 the proxy measures of these concepts cannot be generalized as they vary significantly across
22 countries. Several studies reveal that the relationship varies even among transient economies that
23 are expected to face similar growth challenges (Ozturk and Acaravci, 2010; Palamalai et al.,

1 2014; Sinha, 2014; Sinha and Bhattacharya, 2014; Sinha and Mehta, 2014; Omri et al., 2015;
2 Sinha, 2015).

3 In the light of the above discussion, this paper studies the causal association between
4 economic growth, trade openness, environmental condition and human development in BRIC
5 countries. We employ the extended Cobb-Douglas production function approach by Omri et al.
6 (2015), where economic growth depends on human development indicator, trade openness, gross
7 capital formation, and energy consumption. This particular model permits us to discover the
8 causal association among the variables: economic growth, emission level, human development
9 indicator, and trade openness. These variables are selected for capturing the attributes of BRIC
10 countries. This study accordingly contributes to the literature on energy economics by
11 demonstrating an integrated approach to scrutinize the four-way associations between economic
12 growth, CO₂ emissions, human development indicator, and trade openness in the BRIC countries
13 by using the simultaneous-equation models with panel econometric techniques over the period
14 1980–2013. Consequently, the results of this study can prove to be beneficial for the
15 policymakers to come out with an effective policy-level decision for endorsing long-term
16 economic growth for BRIC nations. By far, the studies carried out for BRIC nations have largely
17 ignored the aspects of human development and majorly focused on the aspects of economic
18 growth (Tamazian et al., 2009; Pao and Tsai, 2010, 2011a; Cowan et al., 2014; Sebri and Ben-
19 Salha, 2014). According to the latest study by Azahaf and Schraad-Tischler (2012), the
20 sustainable development framework in the BRIC nations needs reconsideration, as economists
21 are posing doubts regarding the convergence of income in these nations (Mpoyi, 2012). During
22 the course of economic growth, economists are of the opinion that the sustainable development
23 targets are largely being compromised (Rowlands, 2012). Chakravarty and Mandal (2016) talked

1 about this issue in their recent study, and they have indicated the importance of considering
2 developmental aspects while analyzing the economic growth scenario in BRIC countries. In this
3 kind of a situation, considering the human development aspect within the framework of
4 economic growth and environmental emission may result in significant policy implications. As
5 BRIC nations are also in the process of building several trade linkages with less developed
6 nations for improving the scenario of development in those nations (De Castro, 2012; Çakır and
7 Kabundi, 2013), it may be required to revisit their own sustainable development framework at
8 the very beginning. When these characteristics of the BRIC nations are considered, they
9 adequately comply with the model specification.

10 This study also contributes to the literature by addressing the inherent endogeneity
11 problem which researchers argue about when using simultaneous equation modeling. From the
12 methodological point of view, this study employs the generalized method of moments (GMM)
13 technique, which allows us to get over the endogeneity issue.

14 The structure of the article is as follows: Section 2 deals with the review of relevant
15 literature, Section 3 delineates the econometric techniques and data, Section 4 illustrates the
16 empirical findings, and Section 5 summarizes the article with concluding remarks.

17 **2. Literature review**

18 The extant literature working on the nexus between economic growth, emission level,
19 human development indicator and trade-openness have been carried out in silos, and nearly all of
20 the econometric models have ignored the social parameters to a great extent. Moreover, the
21 causality among these variables also continues to be ambiguous due to varied results of cross-
22 sectional and time series studies that took place in different countries. BRIC, being a significant
23 emerging economy cluster (46% of the world population resides in these countries), has not been

1 studied extensively for these dimensions, especially for human resource development.
2 Consequently, the literature review has been divided into six subsections a) Carbon emission and
3 economic growth; b) Carbon emission and human development; c) Human Development and
4 Trade; d) Economic Growth and Trade; e) Human Development and Economic Growth; and f)
5 Carbon Emission and Trade. We will discuss them in the next subsections.

6 **2.1. Carbon emission and economic growth**

7 The relationship between carbon emission and economics growth has been widely
8 studied for more than two decades. However, the empirical results vary widely mainly due to
9 different sets of underlying variables. In the context of the association between environmental
10 degradation and economic growth, Environmental Kuznets Curve (EKC) hypothesis is one of the
11 extensively researched hypotheses. According to this hypothesis, environmental degradation
12 starts at the earliest stage of economic growth, grows with the rise in income, and once the
13 income reaches a certain point, i.e. the turnaround point, the environmental degradation starts to
14 decline. Therefore, the generally accepted form of EKC is inverted U-shaped. Galeotti et al.
15 (2006) studied the link between carbon emission and economic growth for the OECD and non-
16 OECD countries. They find evidence for the EKC only for the OECD countries. Azomahou et al.
17 (2006) examine the EKC hypothesis for CO₂ emission using a non-parametric approach. They
18 use data for 100 countries over the period 1960–1996 and found some evidence of the EKC
19 hypothesis. The studies considered only bivariate relationship and obtained results that support
20 EKC (Pao and Tsai, 2010). For the advocates of economic growth, EKC hypothesis became an
21 empirical tool to favor economic growth at the cost of CO₂ emission. However, studies by Ekins
22 (1997), Stern (2000), Ozturk and Acaravci (2010), Sinha (2014), Sinha and Bhattacharya (2014),
23 Sinha and Mehta (2014), Sinha (2015) and others obtained different relationship between CO₂

1 emission and economic growth thus weakening the equivocal hold of EKC. However, empirical
2 study by Tamazian et al. (2009) supported the EKC hypothesis for BRIC nations and argues that
3 economic development has reduced environment degradation in these countries. Since such
4 bivariate studies are likely to suffer from endogeneity issue, the present study has been chipped
5 with suitable instrumental variable.

6 **2.2. Carbon emission and human development**

7 Carbon emission gave rise to global health concern which is a vital indicator of human
8 development. Desai (1995) developed an ‘index of intensity of environmental exploitation’ (p.
9 23). Neumayer (2001) connected the Human Development Index with carbon emission in such a
10 way to check whether a country is ‘mortgaging the choices of future generations.’ Most of these
11 studies have focused on integrating an emission factor in calculating the Human Development
12 Index. Few studies by Hill et al. (2009), Woodcock et al. (2009), Smith et al. (2010) and others
13 have quantified the human development cost and its causal association with climate change and
14 paved way for policy change in respective countries. As human resource is an important asset,
15 aspiration of BRIC countries to leap forward in economic ranking entails it important to
16 understand the association between the two, but the association is partial. This paper tries to
17 visualize these variables in an entire framework.

18 **2.3. Carbon emission and trade**

19 Studies incorporating trade as a variable in testing the EKC hypothesis include Grossman
20 and Krueger (1991), Lucas et al. (1992), Wyckoff and Roop (1994), Suri and Chapman (1998),
21 and Nohman and Antrobus (2005). Most of these studies intuitively show that increase in trade
22 should result in higher pollution. While this intuition has been invalidated empirically for local
23 pollutants (like SO₂ and NO₂) but for global pollutant i.e., CO₂, the relationship is positive

1 Frankel and Rose (2005). In the Indian context, Palamalai et al. (2014) identified a bidirectional
2 relationship between trade and carbon emission. The causality cannot be generalized considering
3 varied results obtained by Jalil and Feridun (2011), where they obtained a negative relation
4 between CO₂ emission and trade development in China. Therefore, it is interesting to decipher
5 who can and who cannot gain from trade at the cost of environment.

6 **2.4. Human development and trade**

7 Bhagwati and Daly (1993) and Lash (1997) in their studies showed that pro-free-trade is
8 either a zero-sum game where “the rich grow richer and the poor become poorer,” or trade at
9 best “lifts all boats,” but it promotes inequality. They also emphasized that trade is a major
10 source of environmental degradation. Seminal research by Grossman (2003) debunked this
11 environmental degradation story. Grossman (2003) showed strong empirical evidence that trade-
12 inspired growth increases the per-capita income of developing countries. Although these studies
13 mentioned about the role of trade in human development, they never explicitly tested for it.
14 Davies and Quinlivan (2006) provided evidence for positive relationship between trade and
15 human development mediated by per capita income. In contrast, recent WTO 2014 report
16 dismisses any relationship of trade with health, human development, inequality or environmental
17 performance. For BRIC nations there is a dearth of literature that talks about these two
18 parameters along with others which make it essential to study them in a holistic framework.

19 **2.5. Economic growth and trade**

20 According to Stiglitz (1998, p. 36), “most specifications of empirical growth regressions
21 find that some indicator of external openness-whether trade ratios or indices or price distortions
22 or average tariff level is strongly associated with per-capita income growth.” The literature on
23 trade openness and economic growth have tried to check this association by: (1) constructing

1 alternative indicators of openness (Dollar, 1992; Sachs and Warner, 1995); (2) testing robustness
2 by using a wide range of measures of openness, including subjective indicators (Edwards, 1992,
3 1998); and (3) comparing convergence experience among groups of liberalizing and non-
4 liberalizing countries (Ben-David, 1993). This convergence literature is generally credited with
5 finding significant relationship between trade and economic growth than the other two strands,
6 but most of the literature available till date equivocally supports the bidirectional relation
7 between economic growth and Trade and none has used the BRIC countries. Recent studies by
8 Yucel (2009) and Shahbaz et al. (2013) investigated the causality between economic growth,
9 financial development and trade openness in Turkey and China respectively. In the context of
10 BRIC, Mercan et al. (2013) presented panel data analysis in support of unidirectional
11 relationship between trade openness and economic growth.

12 **2.6. Human development and economic growth**

13 Human development is long understood to be an important input for economic growth.
14 Preliminary empirical evidence of the interaction between the two came from Ehrlich and Lui
15 (1991) and Barro (1996). They took life expectancy as a health indicator and established a
16 conceptual framework by instilling health in growth theory. Ranis et al. (2000) showed the
17 connections between economic growth (EG) and human development (HD) form two chains, the
18 EG to HD chain and the HD to EG chain. They used a cross-country regression to show a
19 significant relationship in both directions. Their study establishes a two-way causality which
20 gives rise to “virtuous or vicious cycles”, with high or low levels on HD and EG reinforcing each
21 other. On the other hand, studies by Mayer (2001), Bloom et al. (2004) and Weil (2005) showed
22 evidences for unidirectional causality between health as a proxy for human development and
23 economic growth. Thus the link between two indicators is inarguably valid for developing as

1 well as developed countries (Bhargava et al., 2001). However, we have not come across any
2 study, which talks about human development along with trade, carbon emission in economic
3 growth studies. This paper is an attempt to explore the role of human development among other
4 parameters of growth.

5 **3. Econometric techniques**

6 **3.1. Model specification**

7 For analyzing the causal association between economic growth, CO₂ emission, trade
8 volume, and human development indicator for BRIC countries, we used an extended Cobb-
9 Douglas production function as per Omri et al. (2015):

$$10 \quad Y = AK^\alpha E^\lambda L^\beta e^\mu \quad (1)$$

11 Where, Y is the GDP of the countries, A is the technological advancement, K is capital formation,
12 E is energy consumption, L is number of labors, and e is error term. α , β , and λ are the respective
13 elasticities of capital, labor, and energy consumption, and we relax the assumption of constant
14 return to scale, as it is not mandatory for this model. In a constant technological regime, scale of
15 industrial emission is directly proportionate to energy consumption (Taft, 1952), such as
16 $E = xC$, C is the CO₂ emissions, and x is time-invariant constant. On the other hand, for the
17 BRIC countries, the technological innovation is largely dependent on the technology transfers
18 via foreign direct investment (FDI) route (Ranjan and Agrawal, 2011). Consequently, we can
19 write

$$20 \quad A(t) = \varphi \cdot T(t) \quad (2)$$

21 Where φ is time-invariant constant and T is volume of trade.

22 In the similar way, the amount of people in working condition can be derived based on the total
23 population and the human development index (HDI) of any country in a linear fashion (Ranis et

1 al., 2006), such as $L(t) = cP(t).H(t)$, P is the population, H is the HDI of the country, and c is
 2 time-invariant constant.

3 Now substituting the values in Eq. (1) reveals:

$$4 \quad Y = x\varphi c.T(t).H(t)^{\theta_1}C(t)^{\theta_2}K(t)^\alpha P(t)^\beta e^\mu \quad (3)$$

5 Firstly, Eq. (3) has been transformed into per capita terms by dividing both sides by P .

6 Now, the linearized Cobb-Douglas function for panel data analysis becomes:

$$7 \quad \ln Y_{it} = \sigma_1 + \sigma_2 \ln C_{it} + \sigma_3 \ln H_{it} + \sigma_4 \ln T_{it} + \sigma_5 \ln K_{it} + \varepsilon_t \quad (4)$$

8 Where, $i = 1, \dots, n$ denotes BRIC countries, and $t = 1, \dots, T$ denotes duration of the study, i.e.
 9 1980-2013.

10 This production function in Eq. (4) is used to develop empirical models to simultaneously
 11 estimate the interactions between per capita income, per capita emission, and inequality in
 12 energy intensity. These models are designed based on the existing literature, which we have
 13 already discussed. While estimating quadrilateral linkage between economic growth, emissions,
 14 trade, and health, square of per capita income (Y^2), capital (K), health expenditure (HEX), energy
 15 consumption (E), foreign direct investment (FDI), and exchange rate (EX) have been used as
 16 instrumental variables. The four models for assessing this linkage are:

$$17 \quad \ln Y_{it} = \sigma_1 + \sigma_2 \ln C_{it} + \sigma_3 \ln H_{it} + \sigma_4 \ln T_{it} + \sigma_5 \ln K_{it} + \varepsilon_t \quad (5)$$

$$18 \quad \ln C_{it} = \sigma_1 + \sigma_2 \ln Y_{it} + \sigma_3 \ln Y_{it}^2 + \sigma_4 \ln H_{it} + \sigma_5 \ln T_{it} + \sigma_6 \ln K_{it} + \sigma_7 \ln E_{it} + \varepsilon_t \quad (6)$$

$$19 \quad \ln H_{it} = \sigma_1 + \sigma_2 \ln Y_{it} + \sigma_3 \ln C_{it} + \sigma_4 \ln T_{it} + \sigma_5 \ln HEX_{it} + \varepsilon_t \quad (7)$$

$$20 \quad \ln T_{it} = \sigma_1 + \sigma_2 \ln Y_{it} + \sigma_3 \ln C_{it} + \sigma_4 \ln H_{it} + \sigma_5 \ln EX_{it} + \sigma_6 \ln FDI_{it} + \varepsilon_t \quad (8)$$

21 In the above equations, the subscript $i = 1 \dots N$ denotes the country and $t = 1 \dots T$ denotes
 22 the time period. Eq. (6) states that economic growth (Y), human development indicator (H),
 23 volume of trade (T), gross capital formation (K), and energy consumption (E) are the driving

1 forces of CO₂ emissions (*C*) (e.g. Smith, 1993; Harbaugh et al., 2002; Munksgaard et al., 2005).
2 Eq. (7) states that human development (*H*) depends on economic growth (*Y*), CO₂ emissions (*C*),
3 volume of trade (*T*), and out-of-pocket health expenditure (*HEX*) (e.g. Messier et al., 2004;
4 Davies and Quinlivan, 2006). Eq. (8) states that volume of trade (*T*) depends on economic
5 growth (*Y*), CO₂ emissions (*C*), human development indicator (*H*), exchange rate (*EX*), and
6 foreign direct investment (*FDI*) (e.g. Aizenman and Noy, 2006; Bogin et al., 2007).

7 The models represented by Eq. (5) to (8) are simultaneously estimated by generalized
8 method of moments (GMM) technique. Apart from efficiency of this technique for estimation of
9 multiple linkages in a panel dataset, it also allows us to make use of instrumental variables, in
10 order to get rid of endogeneity problems.

11 Though GMM always provides us with the opportunity to carry out an empirical analysis
12 even in the presence of random heteroscedasticity, diagnostic tests have been used in this study
13 for reconfirmation of the validity of instruments being used and endogeneity. For checking the
14 validity of instruments, Hansen's test of overidentification has been used, and the null hypothesis
15 of this test is that the instruments in the model are appropriate. For checking the endogeneity,
16 Durbin-Wu-Hausman test has been used, and the null hypothesis of this test is that the
17 instruments are endogenous in nature, resulting in misappropriation of the model.

18 **3.2. Unit root tests**

19 With the recent developments in the literature of econometric techniques, panel unit root
20 tests have undergone a transformation in terms of first generation (Levin et al., 2002; Im et al.,
21 2003) and second generation (Pesaran, 2007). This differentiation lies in view of the cross-
22 sectional dependence in the panel data. First generation panel unit root tests assume that the
23 cross-sections in the panel data are independent, whereas second generation panel unit root tests

1 relax this assumption. If there is cross-sectional dependence present in the data, then application
 2 of first generation panel unit root test may produce fallacious results owing to size distortions.
 3 On the other hand, if there is no cross-sectional dependence present in the data, then application
 4 of second generation panel unit root test may produce loss of power. In this study, the latter one
 5 is the case here, and therefore, we employ the first generation panel unit root tests.

6 By and large, Augmented Dickey Fuller (ADF) (Dickey et al., 1991) unit root test is used
 7 to identify the order of integration of time series variables. But it has the inherent difficulty of
 8 low power in discarding the null hypothesis of stationarity, predominantly for relatively
 9 undersized samples, and because of this, we have not employed this test in this study. In place of
 10 ADF unit root test, Levin-Lin-Chu (LLC) (Levin et al., 2002) and Im-Pesaran-Shin (IPS) (Im et
 11 al., 2003) panel unit root tests are employed, as both of the tests are superior in terms of
 12 explanatory power for relatively higher sample size. LLC presumes homogeneity in the
 13 autoregressive coefficients for all data points, while IPS presumes heterogeneity in those
 14 coefficients. LLC offers a panel-base ADF test and restricts α (coefficient of lagged dependent
 15 variable) to maintain it alike throughout cross sections. The test imposes homogeneity on
 16 autoregressive coefficient that points toward the existence/nonexistence of a unit root, whereas
 17 intercept and trend may vary across individual series. The model permits heterogeneity only in
 18 the intercept and is given by

$$19 \Delta X_{i,t} = \partial_i + \alpha X_{i,t-i} + \sum_{j=1}^{p_i} \phi_j X_{i,t-j} + \varepsilon_{i,t} \quad (9)$$

20 where, $X_{i,t}$ is the series for panel members i (1, 2, ..., N) over period t (1, 2, ..., T), and p_i is the
 21 number of lags. The error term ($\varepsilon_{i,t}$) are assumed to be IID (0, σ^2) and to be independent of units
 22 of the sample. The null hypothesis for indicating non-stationarity in this case can be stated as:

$$23 H_0: \alpha_i = 0, \text{ for all } i; \quad H_1: \alpha_i = \alpha < 0, \text{ for all } i$$

1 The IPS test initiates by denoting different ADF regressions for each cross sections:

$$2 \Delta X_{i,t} = \partial_i + \alpha_i X_{i,t-i} + \sum_{j=1}^{p_i} \phi_{i,j} X_{i,t-j} + \varepsilon_{i,t} \quad (10)$$

3 where, $X_{i,t}$ is the series for panel members i (1, 2, ..., N) over period t (1, 2, ..., T), and p_i is the
4 number of lags. The error term ($\varepsilon_{i,t}$) are assumed to be IID (0, σ^2) and to be independent of the
5 units of the sample. Both α and ϕ are permitted to differ in accordance with the cross sections.

6 The null hypothesis for indicating non-stationarity in this case can be stated as:

$$7 H_0: \alpha_i = 0, \text{ for all } i; \quad H_1: \alpha_i = \alpha < 0, \text{ for all } i$$

8 **4. Data and results**

9 **4.1. Data and descriptive statistics**

10 The data used in this study are for BRIC countries covering the period of 1980-2013. We
11 have collected annual data for CO₂ emission, income, trade, capital formation, exchange rate,
12 energy consumption, and out-of-pocket health expenditure from the World Bank indicators, and
13 HDI data from UNDP. Descriptive statistics of the variables for BRIC countries are provided in
14 Table 1.

15

16 **4.2. Results of panel unit root and cointegration tests**

17 As we have discussed earlier, we employ two first generation panel unit root tests on the
18 data. However, prior to conducting the same, we conducted Pesaran (2007) test to check the
19 cross-section dependence in the data. Null hypothesis of this test is that the cross sections are
20 independent, and it is computed based on average of pair-wise correlation coefficients of the
21 ADF regression residuals for each individual unit. The test statistics are recorded in Table 2, and
22 they show that the null hypothesis cannot be rejected. It signifies that the cross sections of all the

1 panels are independent, and therefore, first generation panel unit root tests can be applied for this
2 study.

3 Heterogeneity of various sections is taken care of by LLC test, and the possibility of low
4 power can be overruled because of the data volume. IPS test also takes care of the same, and it
5 has the ability to eradicate the plausible serial correlation in the data. Null hypotheses of both the
6 tests are that the variables are non-stationary and they have unit root(s).

7 *<Insert Table 1 here>*

8 *<Insert Table 2 here>*

9 Results of both of these tests are recorded in Table 3a. It can be seen that the variables are
10 insignificant at level and significant at first difference for both of the tests, thereby indicating
11 their order of integration as one, i.e. the variables are I(1) in nature.

12 *<Insert Table 3a here>*

13 As the variables are I(1) in nature, we can now proceed for cointegration test. To carry
14 out the same, we employ panel cointegration technique of Pedroni (2004). This test provides us
15 with seven statistics (parametric and non-parametric) with an assumption of cross-sectional
16 independence, which has already been verified. As our study is parametric in nature, we are
17 interested in three parametric test statistics, ADF test statistics to be particular. Going by the
18 pooling of tests, we are interested in between-dimension test statistics.

19 Table 3b provides us with the results of cointegration tests being carried out based on the
20 variables specified in Eq. (5) to (8). P-values of the results evidently suggest that the null
21 hypothesis of no cointegration between the variables cannot be rejected. The results state that the
22 variables included in the specified models are not cointegrated.

23 *<Insert Table 3b here>*

1 **4.3. Results of regression tests and discussion**

2 While estimating four way linkages between CO₂ emission, economic growth, trade, and
3 health, instrumental variables are K , Y^2 , E , FDI , HEX , and EX .

4 However, before carrying out the regression analysis, two specific tests are needed to be
5 conducted. As indicated by Omri et al. (2015), two tests are important before proceeding with
6 any simultaneous equation regression model, and those tests are test of endogeneity and test of
7 overidentification. First, to test for endogeneity Durbin-Wu-Hausman (DWH) test has been used
8 and null hypothesis of this test is that endogeneity among variables will have significant impact
9 on ordinary least squares (OLS) estimates. Rejection of this hypothesis signifies that the models
10 require instrumental variable technique. Second, the overidentifying restrictions are tested for
11 verifying the validity of the selected instruments. Hansen test is used for this purpose, and null
12 hypothesis of overidentifying restrictions cannot be rejected, thereby signifying the precision of
13 the instruments being used in the model.

14 Estimation results of Eq. (5) for four countries are recorded in Table 4a. The results show
15 that CO₂ emission has a negative impact on economic growth, and it is evident for Brazil, India,
16 and China. This implies that the economic growth is elastic to CO₂ emissions, and 1% increase in
17 CO₂ emissions causes decrease in economic growth by 1.7334% (Brazil), 0.7553% (India), and
18 0.7473% (China). No significant result was found for Russia. For the panel result, CO₂ emissions
19 have a negative and significant impact on economic growth at 5% level, and 1% increase in CO₂
20 emissions causes decrease in economic growth by 0.2088%. These results show that the
21 environmental degradation is causing harm to the pattern of economic growth, and thereby,
22 addressing the feedback hypothesis of EKC. These results also show that the economic growth
23 pattern in BRIC nations is unsustainable in nature, and the developmental goals in these nations
24 must consider the environmental sustainability aspects more seriously. The results obtained by us

1 are in the similar lines with the findings of Zhang and Cheng (2009), Pao and Tsai (2011), and
2 Sinha (2015).

3 *<Insert Table 4a here>*

4 The coefficients of human development are positive and significant for Brazil, Russia,
5 and China. This implies that the economic growth is elastic to human development, and 1%
6 increase in human development indicator causes increase in economic growth by 5.2094%
7 (Brazil), 19.1633% (Russia), and 7.9154% (China). No significant result was found for India.
8 For the panel result, human development have a positive and significant impact on economic
9 growth at 1% level, and 1% increase in human development indicator causes increase in
10 economic growth by 1.4525%. These results demonstrate the significance of the quality of life of
11 the labor force in the process of achieving economic growth, as the labor force is the major
12 building block of economic growth in any nation. Srinivasan (1994), Ranis et al. (2000),
13 Chontanawat et al. (2008) and others have confirmed this in diverse contexts.

14 The coefficients of trade are positive and significant for all the countries. This implies
15 that the economic growth is elastic to trade volume, and 1% increase in trade causes increase in
16 economic growth by 0.6131% (Brazil), 0.7181% (Russia), 0.3789% (India), and 0.7789%
17 (China). For the panel result, trade have a positive and significant impact on economic growth at
18 5% level, and 1% increase in trade causes increase in economic growth by 0.4366%. The trade
19 linkages formed by the BRIC nations with Africa and other nations are gradually proving out to
20 be fruitful, and this is reflected in these results. Lucas (1988), Schneider (2005) and others have
21 confirmed this in diverse contexts.

22 Finally, the coefficients of capital are positive and significant at 1% level for Brazil,
23 Russia, and India. These results imply that economic growth is elastic to capital formations, and

1 1% rise in the level of capital formation causes increase in economic growth by 2.6771%
2 (Brazil), 0.3439% (Russia), and 1.1362% (India). No significant result was found for China. For
3 the panel result, capital formation have a positive and significant impact on economic growth at
4 1% level, and 1% increase in capital formation causes increase in economic growth by 1.1709%.
5 The growth in output in BRIC nations is adding to their economic growth, and this growth in
6 output has been possible by the continuous flow of FDI from other nations (Chakravarty and
7 Mandal, 2016). The result is consistent with the findings of Omri et al. (2015).

8 Estimation results of Eq. (6) for four countries are recorded in Table 4b. The results show
9 that impact of economic growth on air pollution follows an EKC framework, and it is evident for
10 Brazil and India. Coefficients of economic growth are positive and that of squared economic
11 growth are negative for these two countries only. This implies that for Brazil and India, the
12 environmental degradation is elastic to economic growth, and the change in the slope of EKC is
13 negative, thereby indicating presence of inverted U-shaped EKC. For Russia and China, the
14 evidences for EKC are not found. For the panel result, impact of economic growth on air
15 pollution follows an EKC framework. This result is the extension of the findings by Galeotti and
16 Lanza (1999) and Jayanthakumaran et al. (2012). However, for Russia and China, the results
17 contradict the findings by Caviglia-Harris et al. (2009) and Diao et al. (2009), respectively.

18 *<Insert Table 4b here>*

19 The coefficients of energy consumption are positive and significant for Russia, India, and
20 China. These results imply that CO₂ emission is elastic to energy consumption, and 1% rise in
21 the level of energy consumption causes increase in emission by 2.1021% (India) and 0.9341%
22 (China). No significant result was found for Brazil and Russia. For the panel result, energy
23 consumption have a positive and significant impact on CO₂ emission at 1% level, and 1%

1 increase in energy consumption causes increase in CO₂ emission by 1.2947%. Considering the
2 economic growth pattern of the BRIC nations, it can be seen that the economic growth achieved
3 by these nations is majorly catalyzed by fossil fuel consumption. Therefore, in BRIC nations, the
4 level of ambient air pollution in terms of CO₂ emission is on the rise. The result is consistent
5 with the findings of Pao and Tsai (2011).

6 The coefficients of trade volume are significant in all the cases, and positive for Brazil,
7 Russia, and China, and negative for India. These results imply that CO₂ emission is elastic to
8 trade volume, and 1% rise in the level of trade volume causes increase in emission by 0.2210%
9 (Brazil), 0.0819% (Russia), and 0.1928% (China), and decrease in emission by 0.0590% (India).
10 For the panel result, trade volume have a positive and significant impact on CO₂ emission at 1%
11 level, and 1% increase in trade volume causes increase in CO₂ emission by 0.0980%. At the
12 earliest stages of economic growth, the BRIC nations provided less importance to the
13 developmental aspects in order to attract more foreign investors. In this context, when they
14 started achieving growth in international trade, they also started deteriorating the environmental
15 quality, which is evident in the rising level of CO₂ emission in these nations. The result is
16 consistent with the findings of Sebri and Ben-Salha (2014).

17 Finally, the coefficients of gross capital formation are significant for Brazil, India, and
18 China. These results imply that CO₂ emission is elastic to gross capital formation, and 1% rise in
19 the level of gross capital formation causes increase in emission by 0.3118% (Brazil), and
20 0.2234% (China), and decrease in emission by 0.2086% (India). For the panel result, gross
21 capital formation have a positive and significant impact on CO₂ emission at 1% level, and 1%
22 increase in gross capital formation causes increase in CO₂ emission by 0.0445%. The output
23 generated in these nations are just the result of continuous consumption of fossil fuel, and

1 following this cue, it can be said that the rising level of CO₂ emission in these nations is just a
2 negative byproduct of the production process. The environmentally unsustainable manufacturing
3 practices added to the environmental degradation by means of rising CO₂ emission. The result is
4 an extension of the findings by Mehrara et al. (2011).

5 *<Insert Table 4c here>*

6 Estimation results of Eq. (7) for four countries are recorded in Table 4c. The results show
7 that positive impact of out-of-pocket health expenditure on human development indicator is
8 evident for Brazil, India, and China. This implies that human development is elastic to health
9 expenditure, and 1% increase in health expenditure causes human development indicator to
10 increase by 0.0079% (Brazil), 0.0031% (India), and 0.0011% (China). No significant result was
11 found for Russia. For the panel result, health expenditure has a positive and significant impact on
12 human development at 1% level, and 1% increase in health expenditure causes increase in
13 human development indicator by 0.0067%. With the graduation of time, the policymakers in the
14 BRIC nations started to realize the negative consequences of environmental degradation on the
15 labor force, and the rising health expenditure in these nations reflect this policy decision. With
16 more amount of health expenditure, the healthcare facility gradually turned out to be more
17 affordable to the citizens. At the same time, the rise in economic growth resulted in the rise of
18 disposable income, which was translated into the rise in out-of-pocket health expenditure.
19 Therefore, people started to avail the healthcare facilities more than before, and the rising level
20 of HDI reflected this. The result is consistent with the findings of Schrooten (2011).

21 The coefficients of economic growth are significant and positive for Russia, India, and
22 China. This implies that human development is elastic to economic growth, and 1% increase in
23 economic growth causes human development indicator to increase by 0.0448% (Russia),

1 0.0571% (India), and 0.1019% (China). No significant result was found for Brazil. For the panel
2 result, economic growth has a positive and significant impact on human development at 1%
3 level, and 1% increase in health expenditure causes increase in human development indicator by
4 0.0724%. Though rise in income is a debatable indicator of development, but it may be hard to
5 deny the fact that with rise in economic growth, a nation can implement more number of
6 developmental initiatives. For BRIC nations, rise in economic growth not only opened up several
7 vocational opportunities before the citizens, the betterment and widening of trade linkages
8 helped several export-oriented sectors to grow. This in turn resulted in better lifestyle for the
9 citizens, and this uplifting in the living standard has been reflected in the HDI level of the BRIC
10 nations. The result is consistent with the findings of Ardichvili et al. (2012).

11 The coefficients of trade volume are significant and positive for India and China. This
12 implies that human development is elastic to trade volume, and 1% increase in trade volume
13 causes human development indicator to increase by 0.0110% (India) and 0.0954% (China). No
14 significant result was found for Brazil and Russia. For the panel result, trade volume has a
15 positive and significant impact on human development at 1% level, and 1% increase in trade
16 volume causes increase in human development indicator by 0.1380%. Rise in the trade volume
17 helped in opening up several vocational opportunities in the existing sectors, and also in starting
18 several export-oriented units. This augmentation in the domestic income resulted in a gradual
19 uplifting of the living standard of BRIC nations, and this uplifting has been reflected in the HDI
20 values of these nations. The result is consistent with the findings of Waligóra (2015).

21 Finally, the coefficients of CO₂ emission are significant and negative for Russia, and
22 positive for Brazil and India. This implies that human development is elastic to CO₂ emission,
23 and 1% increase in CO₂ emission causes human development indicator to decrease by 0.0826%

1 (Russia), and to increase by 0.1747% (Brazil) and 0.1874% (India). The latter results can be
2 defined by the green energy initiatives being taken up in these two nations, and this has been
3 driven by the rising amount of CO₂ emissions in these two nations, which forced the
4 policymakers to introduce clean energy initiatives, leading towards better HDI results. No
5 significant result was found for China. For the panel result, CO₂ emission has a negative and
6 significant impact on human development at 1% level, and 1% increase in CO₂ emission causes
7 decrease in human development indicator by 0.0651%. These results partially answer to the
8 questions being raised by Pacini and Silveira (2013).

9 *<Insert Table 4d here>*

10 Estimation results of Eq. (8) for four countries are recorded in Table 4d. The results show
11 that impact of CO₂ emission on trade volume is evident for Brazil, India, and China. This implies
12 that trade volume is elastic to CO₂ emission, and 1% increase in CO₂ emission causes trade
13 volume to decrease by 2.1606% (Brazil), and 2.4687% (India), and increase by 1.8037%
14 (China). No significant result was found for Russia. This increase and decrease in trade volume
15 can be defined in terms of nature of trade being affected by CO₂ emission. When Brazil and
16 India tried to develop in-house green technology for pollution abatement (Ivarsson and Alvstam,
17 2005), China was majorly look forward to technology transfer from abroad (Lema and Lema,
18 2012). For the panel result, CO₂ emission has a positive and significant impact on trade volume
19 at 1% level, and 1% increase in CO₂ emission causes increase in trade volume by 0.3256%.

20 The coefficients of human development are significant and positive for India only. This
21 implies that trade volume is elastic to human development, and 1% increase in human
22 development indicator causes trade volume to increase by 7.4437% (India). No significant result
23 was found for Brazil, Russia, and China. For the panel result, human development has a positive

1 and significant impact on trade volume at 1% level, and 1% increase in human development
2 indicator causes increase in trade volume by 1.8837%. Availability of healthy and comparatively
3 cheap labor force may open up several opportunities before a nation in terms of foreign direct
4 investment. In that way, the trade volume for that nation is bound to rise, and this is evident for
5 the BRIC nations. The result is new considering the existing literature on human development
6 and trade.

7 The coefficients of economic growth are significant and positive for China only. This
8 implies that trade volume is elastic to economic growth, and 1% increase in economic growth
9 causes trade volume to increase by 0.4747% (China). No significant result was found for Brazil,
10 Russia, and India. For the panel result, economic growth has no significant impact on trade
11 volume. For China, it may be the case that the domestic economic growth has been opening
12 several opportunities to increase the trade volume intrinsically, which may not have been
13 possible for the other three BRIC nations. Therefore, this phenomenon cannot be considered a
14 general one for all the four BRIC nations. The result is in the similar lines with Lardy (1995).

15 The coefficients of exchange rate are significant and positive for all the four countries.
16 This implies that trade volume is elastic to exchange rate, and 1% increase in exchange rate
17 causes trade volume to increase by 0.3846% (Brazil), 0.0089% (Russia), 0.0394% (India), and
18 0.0057% (China). These results indicate that lowering the level of protectionism boosts the
19 volume of trade, and it is applicable for all the BRIC nations. For the panel result, exchange rate
20 has a positive and significant impact on trade volume at 1% level, and 1% increase in exchange
21 rate causes increase in trade volume by 0.0137%. The result is in the similar lines with De
22 Grauwe (1988).

1 The coefficients of foreign direct investment are significant and positive for Brazil, India,
2 and China. However, the effect size is nearly negligible and therefore, we will not consider the
3 elasticity values in this case.

4 By and large, results obtained from this study can be summarized based on the individual
5 associations. For the causal association between economic growth and trade volume, feedback
6 hypothesis exists for China, and unidirectional causal association runs from trade volume to
7 economic growth for Brazil, Russia, and India. Taking the causal association between economic
8 growth and CO₂ emission, feedback hypothesis exists for Brazil, India, and China, and neutrality
9 hypothesis exists for Russia. Next, taking the causal association between economic growth and
10 human development, feedback hypothesis exists for Russia and China, unidirectional causal
11 association runs from human development to economic growth for Brazil, and unidirectional
12 causal association runs from economic growth to human development for India. For the causal
13 association between human development and trade volume, feedback hypothesis exists for India,
14 unidirectional causal association runs from trade volume to human development for China, and
15 neutrality hypothesis exists for Brazil and Russia. Now, for the causal association between
16 human development and CO₂ emission, feedback hypothesis exists for Russia, unidirectional
17 causal association runs from CO₂ emission to human development for India and Brazil, and
18 neutrality hypothesis exists for China. Finally, for the causal association between trade volume
19 and CO₂ emission, feedback hypothesis exists for Brazil, India, and China, and unidirectional
20 causal association runs from trade volume to CO₂ emission for Russia.

21 *<Insert Figure 1 here>*

22 As a final point, conclusive results of this study are, (i) bidirectional causality exists
23 between CO₂ emissions and economic growth, (ii) bidirectional causality exists between CO₂

1 emissions and human development, (iii) bidirectional causality exists between CO₂ emission and
2 trade volume, (iv) bidirectional causality exists between economic growth and human
3 development, (v) bidirectional causality exists between trade volume and human development,
4 and (vi) unidirectional causality exists from trade volume to economic growth. Figure 1
5 summarizes the aforementioned results. These results confirm the four-way linkages between
6 economic growth, CO₂ emission, human development, and trade volume in BRIC countries for
7 the duration of 1980-2013.

8 **5. Conclusions and policy implications**

9 This study examined the causal associations between economic growth, CO₂ emissions,
10 human development, and trade volume using simultaneous equation panel data model for BRIC
11 countries for the duration of 1980-2013. Structural equations allowed us to examine the influence
12 of (i) CO₂ emission, trade volume, human development, and other variables on economic
13 growth, (ii) economic growth, trade volume, human development, and other variables on CO₂
14 emissions, (iii) economic growth, CO₂ emissions, human development, and other variables on
15 trade volume, and (iv) economic growth, CO₂ emissions, trade volume, and other variables on
16 human development.

17 Main findings of the study indicate that bidirectional causality exists between CO₂
18 emissions and economic growth. Feedback hypothesis is supported between CO₂ emissions and
19 human development, trade volume and human development, economic growth and human
20 development, and CO₂ emissions and trade volume. Apart from finding out the unidirectional
21 association from trade volume to economic growth, this study also validated the existence of
22 Environmental Kuznets curve.

1 Policy implications of the study can be put forth based on the directions of the causal
2 associations being established in the study. Presence of feedback link between CO₂ emissions
3 and economic growth indicates that environmental pressure in the form of ambient air pollution
4 can affect the level of hygienic state of the labor force, and thereby, affecting the economic
5 growth. In order to mitigate this effect, the policymakers should put forth more emphasis on
6 green energy generation initiatives, which can either be developed in-house, or can be imported
7 via technology transfer. Empirical evidence of the latter can be visualized by the feedback
8 between CO₂ emissions and trade volume, and CO₂ emissions and human development,
9 respectively. By importing green technologies, the state of hygiene of the labor force can be
10 maintained, and this import need has been generated by the present state of human development
11 in BRIC nations. This has been validated by the feedback between trade volume and human
12 development. Finally, apart from technology transfer, the other forms of trade can boost up the
13 economic growth, by catalyzing the FDI spillovers, which is indicated by the unidirectional
14 causal association from trade volume to economic growth.

15

1 **References**

- 2 Aizenman, J. Noy, I., 2006. FDI and trade – Two-way linkages?. The Quarterly Review of
3 Economics and Finance, 46(3), 317-337.
- 4 Ardichvili, A., Zavyalova, E., Minina, V., 2012. Human capital development: comparative
5 analysis of BRICs. European Journal of Training and Development, 36(2/3), 213-233.
- 6 Azahaf, N., Schraad-Tischler, D., 2012. Governance Capacities in the BRICS. Bertelsmann
7 Stiftung. Retrieved from <http://www.sgi-network.org/brics/?GovernanceCapacities>
- 8 Barro, R., 1996. Health and economic growth. Cambridge, MA: Harvard University.
- 9 Ben-David, D., 1993. Equalizing exchange: Trade liberalization and income convergence. The
10 Quarterly Journal of Economics, 108(3), 653-679.
- 11 Bhargava, A., Jamison, D.T., Lau, L.J., Murray, C.J., 2001. Modeling the effects of health on
12 economic growth. Journal of Health Economics, 20(3), 423-440.
- 13 Bloom, D.E., Canning, D., Sevilla, J., 2004. The effect of health on economic growth: a
14 production function approach. World Development, 32(1), 1-13.
- 15 Bogin, B., Silva, M.I.V., Rios, L., 2007. Life history trade-offs in human growth: Adaptation or
16 pathology? American Journal of Human Biology, 19(5), 631-642.
- 17 Çakır, M.Y., Kabundi, A., 2013. Trade shocks from BRIC to South Africa: A global VAR
18 analysis. Economic Modelling, 32, 190-202.
- 19 Caviglia-Harris, J.L., Chambers, D., Kahn, J.R., 2009. Taking the “U” out of Kuznets: A
20 comprehensive analysis of the EKC and environmental degradation. Ecological
21 Economics, 68(4), 1149-1159.
- 22 Chakravarty, D., Mandal, S. K., 2016. Estimating the relationship between economic growth and
23 environmental quality for the brics economies-a dynamic panel data approach. The
24 Journal of Developing Areas, 50(5), 119-130.

- 1 Cowan, W.N., Chang, T., Inglesi-Lotz, R., Gupta, R., 2014. The nexus of electricity
2 consumption, economic growth and CO₂ emissions in the BRICS countries. *Energy*
3 *Policy*, 66, 359-368.
- 4 Davies, A., Quinlivan, G., 2006. A panel data analysis of the impact of trade on human
5 development. *The Journal of Socio-Economics*, 35(5), 868-876.
- 6 De Castro, T., 2012. Trade cooperation indicators: development of BRIC bilateral trade flows.
7 *International Review of Business Research Papers*, 8(1), 211-223.
- 8 De Grauwe, P., 1988. Exchange rate variability and the slowdown in growth of international
9 trade. *Staff Papers-International Monetary Fund*, 35(1), 63-84.
- 10 Diao, X.D., Zeng, S.X., Tam, C.M., Tam, V.W., 2009. EKC analysis for studying economic
11 growth and environmental quality: a case study in China. *Journal of Cleaner Production*,
12 17(5), 541-548.
- 13 Dickey, D.A., Jansen, D.W., Fuller, W.A., 1991. A Primer on Cointegration with an Application
14 to Money and Income. *Review Federal Reserve Bank of ST. Louis*, 73(2), 58-78.
- 15 Dollar, D., 1992. Outward-oriented developing economies really do grow more rapidly: evidence
16 from 95 LDCs, 1976-1985. *Economic Development and Cultural Change*, 40(3), 523-
17 544.
- 18 Edwards, S., 1992. Trade orientation, distortions and growth in developing countries. *Journal of*
19 *Development Economics*, 39(1), 31-57.
- 20 Edwards, S., 1998. Openness, productivity and growth: what do we really know? *The Economic*
21 *Journal*, 108(447), 383-398.
- 22 Ehrlich, I., Lui, F.T., 1991. Intergenerational trade, longevity, and economic growth. *Journal of*
23 *Political Economy*, 99(5), 1029-1059.

- 1 Ekins, P., 1997. The Kuznets curve for the environment and economic growth: examining the
2 evidence. *Environment and Planning A*, 29(5), 805-830.
- 3 Frankel, J.A., Rose, A.K., 2005. Is trade good or bad for the environment? Sorting out the
4 causality. *Review of Economics and Statistics*, 87(1), 85-91.
- 5 Galeotti, M., Lanza, A., 1999. Richer and cleaner? A study on carbon dioxide emissions in
6 developing countries. *Energy Policy*, 27(10), 565-573.
- 7 Grossman, G., 2003. Trade and the Environment: Friends or Foes? in Quinlivan, G., Herr, H.
8 (Eds.). *Economic Directions*. Center for Economic and Policy Education, Alex G.
9 McKenna School of Business, Economics, and Government at Saint Vincent College.
- 10 Grossman, G.M., Krueger, A.B., 1991. Environmental impacts of a North American free trade
11 agreement (No. w3914). National Bureau of Economic Research.
- 12 Harbaugh, W.T., Levinson, A., Wilson, D.M., 2002. Reexamining the empirical evidence for an
13 environmental Kuznets curve. *Review of Economics and Statistics*, 84(3), 541-551.
- 14 Hill, J., Polasky, S., Nelson, E., Tilman, D., Huo, H., Ludwig, L. ... & Bonta, D., 2009. Climate
15 change and health costs of air emissions from biofuels and gasoline. *Proceedings of the*
16 *National Academy of Sciences*, 106(6), 2077-2082.
- 17 Im, K.S., Pesaran, M.H., Shin, Y., 2003. Testing for Unit Roots in Heterogeneous Panels.
18 *Journal of Econometrics*, 115(1), 53-74.
- 19 Ivarsson, I., Alvstam, C.G., 2005. Technology transfer from TNCs to local suppliers in
20 developing countries: a study of AB Volvo's truck and bus plants in Brazil, China, India,
21 and Mexico. *World Development*, 33(8), 1325-1344.
- 22 Jalil, A., Feridun, M., 2011. The impact of growth, energy and financial development on the
23 environment in China: A cointegration analysis. *Energy Economics*, 33(2), 284-291.

1 Jayanthakumaran, K., Verma, R., Liu, Y., 2012. CO₂ emissions, energy consumption, trade and
2 income: a comparative analysis of China and India. *Energy Policy*, 42, 450-460.

3 Lardy, N.R., 1995. The role of foreign trade and investment in China's economic transformation.
4 *The China Quarterly*, 144, 1065-1082.

5 Lash, W.H., 1997. *Green Showdown at the WTO*. Center for the Study of American Business,
6 Washington University.

7 Lema, R., Lema, A., 2012. Technology transfer? The rise of China and India in green technology
8 sectors. *Innovation and Development*, 2(1), 23-44.

9 Levin, A., Lin, C.F., Chu, C.S., 2002. Unit Root Tests in Panel Data: Asymptotic and Finite
10 Sample Properties. *Journal of Econometrics*, 108(1), 1-24.

11 Lucas, R.E., Wheeler, D., Hettige, H., 1993. *Economic Development, Environmental Regulation,
12 and the International Migration of Toxic Industrial Pollution, 1960-88 (Vol. 1062)*. World
13 Bank Publications.

14 Mahalanobis, P.C., 1955. The approach of operational research to planning in India. *Sankhyā:
15 The Indian Journal of Statistics (1933-1960)*, 16(1/2), 3-130.

16 Mayer, D., 2001. The long-term impact of health on economic growth in Latin America. *World
17 Development*, 29(6), 1025-1033.

18 Mehrara, M., Musai, M., Amiri, H., 2011. Pollution, Energy Consumption and Economic
19 Growth: evidence from India, China and Brazil. *Journal of Social and Development
20 Sciences*, 2(5), 233-242.

21 Mercan, M., Gocer, I., Bulut, S., Dam, M., 2013. The effect of openness on Economic growth for
22 BRIC-T countries: Panel data analysis. *Eurasian Journal of Business and Economics*,
23 6(11), 1-14.

- 1 Messier, M.L., Li, A., Nattie, E.E., 2004. Inhibition of medullary raphe serotonergic neurons has
2 age-dependent effects on the CO₂ response in newborn piglets. *Journal of Applied*
3 *Physiology*, 96(5), 1909-1919.
- 4 Mpoyi, R.T., 2012. The Impact of the “BRIC Thesis” and the Rise of Emerging Economies on
5 Global Competitive Advantage: Will There Be a Shift from West to East? *Journal of*
6 *Applied Business and Economics*, 13(3), 36-47.
- 7 Munksgaard, J., Pade, L.L., Minx, J., Lenzen, M., 2005. Influence of trade on national CO₂
8 emissions. *International Journal of Global Energy Issues*, 23(4), 324-336.
- 9 Nahman, A., Antrobus, G., 2005. Trade and the environmental Kuznets curve: is Southern Africa
10 a pollution haven? *South African Journal of Economics*, 73(4), 803-814.
- 11 Omri, A., Daly, S., Rault, C., Chaibi, A., 2015. Financial development, environmental quality,
12 trade and economic growth: What causes what in MENA countries. *Energy Economics*,
13 48, 242-252.
- 14 Ozturk, I., Acaravci, A., 2010. CO₂ emissions, energy consumption and economic growth in
15 Turkey. *Renewable and Sustainable Energy Reviews*, 14(9), 3220-3225.
- 16 Pacini, H., Silveira, S., 2013. Carbon Intensities of Economies from the Perspective of Learning
17 Curves. *Challenges in Sustainability*, 1(2), 94-103.
- 18 Palamalai, S., Ravindra, I.S., Prakasam, K., 2014. Relationship between Energy Consumption,
19 CO₂ Emissions, Economic Growth and Trade in India. *Journal of Economic & Financial*
20 *Studies*, 3(2), 1-17.
- 21 Pao, H.T., Tsai, C.M., 2010. CO₂ emissions, energy consumption and economic growth in BRIC
22 countries. *Energy Policy*, 38(12), 7850-7860.

- 1 Pao, H.T., Tsai, C.M., 2011a. Multivariate Granger causality between CO₂ emissions, energy
2 consumption, FDI (foreign direct investment) and GDP (gross domestic product):
3 evidence from a panel of BRIC (Brazil, Russian Federation, India, and China) countries.
4 Energy, 36(1), 685-693.
- 5 Pao, H.T., Tsai, C.M., 2011b. Modeling and forecasting the CO₂ emissions, energy consumption,
6 and economic growth in Brazil. Energy, 36(5), 2450-2458.
- 7 Pedroni, P., 2004. Panel Cointegration: Asymptotic and Finite Sample Properties of Pooled Time
8 Series Tests with an Application to the PPP Hypothesis: New Results. Econometric
9 Theory, 20(3), 597-627.
- 10 Pesaran, M.H., 2007. A simple panel unit root test in the presence of cross-section dependence.
11 Journal of Applied Econometrics, 22(2), 265-312.
- 12 Ranis, G., Stewart, F., Ramirez, A., 2000. Economic growth and human development. World
13 Development, 28(2), 197-219.
- 14 Ranis, G., Stewart, F., Samman, E., 2006. Human development: beyond the human development
15 index. Journal of Human Development, 7(3), 323-358.
- 16 Ranjan, V., Agrawal, G., 2011. FDI Inflow Determinants in BRIC countries: A Panel Data
17 Analysis. International Business Research, 4(4), 255-263.
- 18 Rowlands, D., 2012. Individual BRICS or a collective bloc? Convergence and divergence
19 amongst 'emerging donor' nations. Cambridge Review of International Affairs, 25(4),
20 629-649.
- 21 Sachs, J.D., Warner, A., Åslund, A., Fischer, S., 1995. Economic reform and the process of
22 global integration. Brookings Papers on Economic Activity, 1995(1), 1-118.

- 1 Schneider, P.H., 2005. International trade, economic growth and intellectual property rights: A
2 panel data study of developed and developing countries. *Journal of Development*
3 *Economics*, 78(2), 529-547.
- 4 Schrooten, M., 2011. Brazil, Russia, India, China and South Africa: Strong Economic Growth-
5 Major Challenges. *DIW Economic Bulletin*, 1(4), 18-22.
- 6 Sebri, M., Ben-Salha, O., 2014. On the causal dynamics between economic growth, renewable
7 energy consumption, CO₂ emissions and trade openness: Fresh evidence from BRICS
8 countries. *Renewable and Sustainable Energy Reviews*, 39, 14-23.
- 9 Shahbaz, M., Khan, S., Tahir, M.I., 2013. The dynamic links between energy consumption,
10 economic growth, financial development and trade in China: fresh evidence from
11 multivariate framework analysis. *Energy Economics*, 40, 8-21.
- 12 Sinha, A., 2014. Carbon Emissions and Mortality Rates: A Causal Analysis for India (1971-
13 2010). *International Journal of Economic Practices and Theories*. 4(4), 486-492.
- 14 Sinha, A., Bhattacharya, J., 2014. Is Economic Liberalization Causing Environmental
15 Degradation in India? An Analysis of Interventions. *Journal of Applied Business and*
16 *Economics*. 16(5), 121-136.
- 17 Sinha, A., Mehta, A., 2014. Causal analysis of India's Energy-led growth and CO₂ emission
18 (1960-2010). *Indian Journal of Economics & Business*. 13(1), 81-89.
- 19 Sinha, A., 2015. Modeling Energy Efficiency and Economic Growth: Evidences from India.
20 *International Journal of Energy Economics and Policy*. 5(1), 96-104.
- 21 Smith, K.R., 1993. Fuel combustion, air pollution exposure, and health: the situation in
22 developing countries. *Annual Review of Energy and the Environment*, 18(1), 529-566.

1 Smith, K.R., Jerrett, M., Anderson, H.R., Burnett, R.T., Stone, V., Derwent, R. ... Thurston, G.,
2 2010. Public health benefits of strategies to reduce greenhouse-gas emissions: health
3 implications of short-lived greenhouse pollutants. *The Lancet*, 374(9707), 2091-2103.

4 Srinivasan, T.N., 1994. Human development: a new paradigm or reinvention of the wheel? *The*
5 *American Economic Review*, 84(2), 238-243.

6 Stern, D.I., 2000. A multivariate cointegration analysis of the role of energy in the US
7 macroeconomy. *Energy Economics*, 22(2), 267-283.

8 Suri, V., Chapman, D., 1998. Economic growth, trade and energy: implications for the
9 environmental Kuznets curve. *Ecological Economics*, 25(2), 195-208.

10 Taft Jr, R.W., 1952. Linear free energy relationships from rates of esterification and hydrolysis
11 of aliphatic and ortho-substituted benzoate esters. *Journal of the American Chemical*
12 *Society*, 74(11), 2729-2732.

13 Tamazian, A., Chousa, J.P., Vadlamannati, K.C., 2009. Does higher economic and financial
14 development lead to environmental degradation: evidence from BRIC countries. *Energy*
15 *Policy*, 37(1), 246-253.

16 The World Bank, 2007. *The Little Green Data Book 2007*. The World Bank, Washington, DC.

17 Waligóra, K., 2015. Developed societies=happy societies? Growth or development-BRIC.
18 *Journal of International Studies*, 8(1), 114-125.

19 Weil, D.N., 2005. Accounting for the effect of health on economic growth. *Quarterly Journal of*
20 *Economics*, 122(3), 1265-1306.

21 Woodcock, J., Edwards, P., Tonne, C., Armstrong, B.G., Ashiru, O., Banister, D. ... Roberts, I.,
22 2009. Public health benefits of strategies to reduce greenhouse-gas emissions: urban land
23 transport. *The Lancet*, 374(9705), 1930-1943.

- 1 World Bank (2015). World Bank Indicators. Retrieved from <http://data.worldbank.org/indicator>
- 2 Yucel, F., 2009. Causal relationships between financial development, trade openness and
- 3 economic growth: the case of Turkey. *Journal of Social Sciences*, 5(1), 33-42.
- 4 Zhang, X.P., Cheng, X.M., 2009. Energy consumption, carbon emissions, and economic growth
- 5 in China. *Ecological Economics*, 68(10), 2706-2712.