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RAPID ECONOMIC GROWTH AT THE COST OF ENVIRONMENT DEGRADATION? – PANEL DATA EVIDIENCE FROM BRIC ECONOMIES

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ABSTRACT

The paper investigates whether the decline in environmental quality in BRIC economies is due to high energy consumption level which is a resultant of rapid economic growth. We answer this using environmental, macroeconomic and financial variables along with Kyoto Protocol indicators based on panel data from 1992 to 2004. The long run equilibrium relationship between energy consumption and economic growth was examined. Through the panel data, feasible general least squares (FGLS) procedure was employed to estimate the environmental degradation caused by the increase in energy consumption. Pooled regression analysis is used to estimate the relationship between energy consumption and growth variables. We study the impact of excessive economic growth rates on energy consumption levels by means of threshold pooled ordinary least squares (POLS) method. Moreover, our analysis also attempts to fulfill the econometric criticism of the Environmental Kuznets Curve faced by Stern (2004).

Our results reveal that higher energy consumption indeed leads to CO2 emission in the countries under consideration. We find that energy consumption is a resultant of rapid economic growth, creating scope for large demand which is caused by increase in investment levels, population, and trade in energy intensive products. We show that rapid economic growth rate further increases the energy consumption levels in BRIC economies. The results of cointegration analysis also confirm these findings. Finally, the inclusion of USA and Japan as a world's largest energy consumers into our analysis does not significantly change the results.

KEYWORDS: CO2 Emissions, Energy Consumption, Economic Growth, BRIC economies.

JEL CLASSIFICATION: Q40, Q41, Q43, O13, O14

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1. Introduction

It is the mad rush for rapid economic growth led by industrialization in emerging economies like India, China , Brazil, Russia (BRIC hereafter) are having a negative impact on the ecological management. It is evident that rapidly growing economies are causing severe pollution problems in the form of emissions of various forms of gases like the CO2. Higher emissions in these countries are a resultant of higher energy consumption. Higher rate of growth of population, rapid industrialization, trade in energy intensive products, increase in number of vehicles as a result of a very high economic growth are the major driving forces towards higher energy consumption.

The economic growth exhibited specially by China and India are exuberant during post 1990s. The higher growth levels have placed these two economies in the different League of Nations altogether. China and India together contributes world's 30% of GDP in US $ constant PPP as on 2003 (World Bank, 2004). In 2006, China is growing at over a growth rate of 10%, India at 9%, while Russia and Brazil at a rate of 7% and 4% respectively (see Fig. 1).

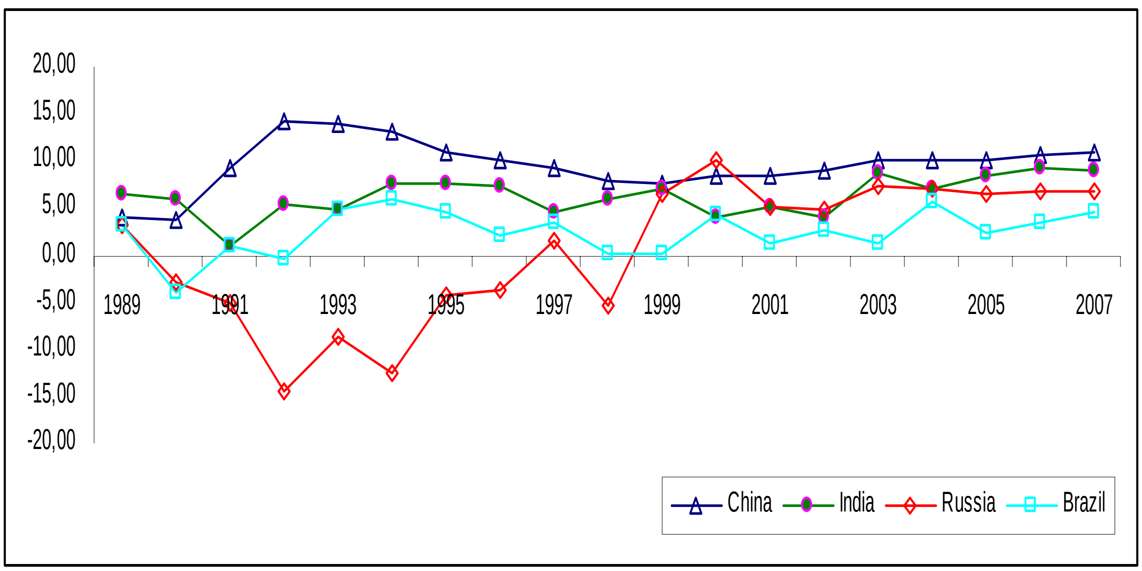

Figure 1: Economic Growth Rates of BRIC Economies

In this context, environmental economists opine that there are environmental costs and damages associated with rapid economic growth which results in expanding of economic activities. This ever increasing consumption demand would have global side effects such as high emissions leading to global warming, greenhouse effects and destruction of forests. The environmental degradation can also add to the problems of imposing higher costs on the poor by increasing the expenditure of health related issues. According to United Nations report, world's poorest 20% of population take this burden which is a resultant of environment degradation. It is also said to have responsible for world's 80% of the diseases due to pollution in the form of water, air and land due to rapid industrialization (United Nations Report, 1999-00).

The problem associated in the case of BRIC economies is that all these nations are in the stage of rapid industrialization which is a resultant of high economic growth led by changes in the structure of economic activities, higher investments and high rate of growth in population. This issue is exactly related and explained by the Environmental Kuznet Curve (EKC). Its hypothesis states that pollution levels increase as the country develops, but begin to decrease as rising incomes pass beyond a turning point. This is reflected as inverted-U curve, expressing the relationship between pollution levels and income. This hypothesis was first proposed by Grossman and Krueger (1992) and restated by them again in 1995. There are many forces which are driving the relationship between environment degradation and economic growth. The upward movement of the curve captures the developing countries that move from agriculturally based economy to industrialization phase. In the next phase, the economy transforms into developed economy and then starts the downward movement of the curve with a shift towards services growth, increase in imports of industrial goods and stabilization of growth rates.

However, this whole premise of economic growth and environment based on EKC was challenged by Stren (2004). He presents a critical history of the EKC. According to him the arguments of EKC do not stand on strong econometric footing. He pointed out that the major weaknesses asscociated with the econometric estimation are heteroskedasticity, omitted variables bias, and issues relating to cointegration analysis. In fact, Stern et al. (1996) and Schmalensee et al. (1998) deal with heteroskedasticity by highlighting that regression residuals were heteroskedastic. Taking their arguments into account, we control for heteroskedasticity problem by using white heteroskedasticity-consistent standard errors and covariance in all our models. We also ensure that our models do not run into the problems of serial correlation. Therefore we check for serial correlation by using Breusch-Godfrey LM test. With regard to the omitted variable bias, we run sensitivity analysis in terms of robustness checks for each model.

Hence this paper tries to answer to the questions raised in the context of BRIC economies. On the first place, we investigate the relationship between the CO2 emission and energy consumption. Then we study the link between energy consumption and economic growth, industrialization and investment activities. We contribute to the literature by assessing whether higher economic growth rates lead to higher energy consumption or not. To further confirm this, we test for long run equilibrium relationship between emissions, energy consumption levels and economic development indicators, followed by causal analysis.

We pay special attention to BRIC economies since they are in the first phase of EKC, where they are experiencing the structural shifts from agriculture to industrial growth. The share of agriculture for India has considerably declined from over 80% in 1950s to around 25% by 2007 and for China the decline in agriculture sector was from round 60% to 25% and industrial share in GDP went up from around 20% to over 50% during the same period of time. In the case of Brazil, its traditional strong hold is industry where its share was around 38% of GDP in 1970 itself. This slightly increased to over 40% in 2007 (WDI, 2007). Added to this, rapid economic growth also fuelled growth in investments. There is substantial growth in investments in BRIC economies, especially in post 1990s. During the same period of time the levels of energy consumption and CO2 emissions have also drastically increased in these economies, exhibiting a relationship between economic growth led by industrialization and environment degradation.

The rest of paper is organized as follows. Section 2 presents the literature review. Section 3 outlines the econometric models and data sources. We report the empirical estimates and results in section 4. Section 5 concludes.

2. Previous Research Findings

There are a considerable number of studies that examine the link between energy consumption and economic growth. Following Kraft and Kraft (1978), there are studies which examined the causal relationship between energy consumption and income with diverse results (Akarca and Long, 1980; Yu and Hwang, 1984; Yu and Choi, 1985; Erol and Yu, 1987; Nachane, Nadkarni and Karnik, 1988; Abosedra and Baghestani, 1989; Hwang and Gum, 1992 and Bentzen and Engsted, 1993). But they all suffer from omitted variables bias. However, Stern (1993) was the first to advocate multivariate setting to understand the relationship between energy consumption and income growth. Prior to the work of Stern, many authors have done similar studies on a large scale sample. For instance, Grossman and Krueger (1991), Lucas et al. (1992), Shafik and Bandyopadhyay (1992), where the first to work on the relationship between the environment degradation and economic growth using cross section time series data. All these studies have taken into account the models specified above. Amongst them, Grossman and Krueger (1991) were the first ones to articulate the concept of Environment degradation and Economic Growth relation which became popular by the name Environment Kuznets Curve (EKC hereafter). They applied a critical test to the hypothesis that greater openness to trade will lead to lower environmental standards in order to retain international competitiveness.

Kolstad and Krautkraemer (1993) point out the fact that there is a dynamic link between the environment, resource use and economic activity. They argue that while resource use (especially energy sources) yields to immediate economic benefits, its negative impact on the environment may be observed in the long run. Selecting the period 1971-1991, Tucker (1995) looked at changes in CO2 versus income in yearly cross-sectional analyses. The study found that the changes in CO2 emissions are clearly related to changes in oil prices, but does not incorporate them into the analysis. The study by Agras and Chapman (1998), takes into account the price of energy. This study highlights the importance of prices and then includes it in econometric EKC framework testing energy-income and CO2-income relationships. These long-run price-income models find that income is no longer relevant indicator of environmental quality or energy demand.

Suri and Chapman (1998) examined the sources of commercial energy consumption, which is the root cause of serious environmental problems. It was found in the study that while both industrializing and industrialized countries have added to their energy requirements by exporting manufactured goods, the growth has been substantially higher in the former. At the same time, industrialized countries have been able to reduce their energy requirements by importing manufactured goods. The exports of manufactured goods by industrialized countries has thus been an important factor in generating the upward sloping portion of the EKC and imports by industrialized countries have contributed to downward slope.

Bernardini and Galli (1998) examined three fundamental factors that led to the decline in intensity of use of energy and materials for emerging Asian economies. They found that these three factors were changes in the structure of final demand, increases in the efficiency of materials and energy use and the substitution of more efficient materials and fuels. Kadnar (2004) in his research based on the energy consumption patterns, a model to predict the future short-term fossil fuel energy needs, using the relationship between consumption, population growth and real gross domestic product (GDP) for two situations (zero or no growth and a 5% sustained economic growth), was developed for Central Asian economies and obtained mixed results.

Recently, Lise and Van Montfort (2006) try to unfold the linkage between energy consumption and GDP by undertaking a cointegration analysis for Turkey with annual data over the period 1970–2003. The analysis shows that energy consumption and GDP are cointegrated. This means that there is a (possibly bi-directional) causality relationship between the two. In this framework Soytas and Sari (2007) investigates the long run Granger causality relationship between economic growth, CO2 emissions and energy consumption in Turkey, controlling for gross fixed capital formation and labor. The most interesting result obtained in the study is that carbon emissions seem to Granger cause energy consumption, but not vice versa.

Similarly, Focacci (2005) proposes an empirical analysis concerning the environmental and energy policies in Brazil, China and India. The study includes ratio analysis using two key ratios namely, emission intensity ratio and energy-intensity ratio to relate to EKC model. The study results show mixed results with respect to application of EKC model for these three economies. It shows that resulting trends in these three countries are different from the other developing countries.

All the research studies suggest that the ever increasing world wide CO2 emissions seem to be intensifying the problem of environment degradation resulting in global warming. This was also highlighted by the Intergovernmental Panel on Climate Change (IPCC, 2007). Since the emissions mainly result from consumption of energy, reduction in energy consumption seems to be the only way of handling this problem. But for an economy to grow, cutting the energy consumption levels seems less likely to be a possibility. This turns the focus on some of the emerging economies like BRIC nations which are exhibiting a rapid economic growth led by investments and industrialization to sacrifice their rapid rate of growth for betterment of environment quality.

3. i. Econometric Models & Data Sources

Going by the objectives of the study, the paper tries to develop models to explain the relationship between pollution which is driven by energy consumption and energy consumption which in turn is driven by growth variables. First, in order to assess the variables affecting CO2 and energy consumption, two different relationships were examined using the period 1992 to 2004:

a. CO2 Equation: GLS with Fixed Effects

$$CO_{2it} = \alpha + \beta_1 \Delta GDP_{it} + \sum_{i=1}^{8} \beta_2 CV_{it} + \varepsilon_{it} \qquad (1)$$

Where,
CO_{2it} = Emission in year “t” for country “i”
ΔGDP_{it} = Economic Growth variable in year “t” for country “i”
CV = Control variable in year “t” for country “i”
ε_{it} = Error term

b. Energy Consumption Equation: Pooled Regression Analysis

$$EC_{it} = \alpha + \beta_1 \Delta GDP_{it} + \sum_{i=1}^{8} \beta_2 CV_{it} + \varepsilon_{it} \qquad (2)$$

Where,
EC_{it} = Energy Consumption in year “t” for country “i”
ΔGDP_{it} = Economic Growth variable in year “t” for country “i”
CV_{it} = Control variables in year “t” for country “i”
ε_{it} = Error term

Our first dependent variable for the equation 1 is CO2 Emissions. The panel data procedure consists of three estimation sets; first, Between Estimates that is captures differences between individuals, but ignores any information within them. It is usually used to estimate long-run coefficients. Second, Fixed Effects (FE) estimates in which it is assumed that the slope of the equation is the same for all individuals, but there are specific intercepts for each of them that it would be correlated or uncorrelated with explanatory variables. This procedure is also well-known as the Least Squares Dummy Variables (LSDV) method (Hsiao, 1986). The third relies on Random Effects (RE) estimates.

In order to distinguish between the FE and RE method, we investigate thorough Hausman test for the null hypothesis that the explanatory variables and individual effects can be uncorrelated. The fixed effects estimates are consistent with the both null and alternative hypotheses, whereas the random effects estimates are only compatible with the null hypothesis. Therefore, RE method is preferred if the null hypothesis holds, otherwise FE method can be applicable.

It is presumed that that the ecological problems is largely driven the by emission of some of the toxic gasses like the CO2. Higher levels of CO2 emissions drastically effect the environment. Thus, we take into account the CO2 emission in kilo tons as the dependent variable which is contributing to the pollution and disturbing the environmental balance. For the second equation, our dependent variable is energy consumption. There are severe environmental threats in most of the developing economies like India and China because of the growing needs in the form of high energy consumption. It is hypothesized in the earlier argument that as energy consumption increases it leads to more emission of some dangerous toxic gases. We take into account energy consumption in kilo tons oil equivalent per country. The direct relationship is presumed between the energy use and CO2 emission in developing economies. Environmental damage almost always hits the hardest to those living in poverty (UN HDR, 1998). We adopt the data for both these variables from World Bank's World Development Indicators 2006.

Beginning with the independent variables, we first concentrate on those variables which are common in both the models. The energy use in emergining economies is largely due to the rapid growth rate of their economies. These higher growth rates are putting increasing pressure on energy consumption in the form of increasing needs. As emerging markets develop and expand, they release increasing quantities of toxic gasses into the atmosphere because of higher energy consumption. Increase in those emissions may eventually be raged by rising GDP, increasing the attractiveness of environmental protection as a consumable. Thus, the GDP growth rates are positively associated with the energy use in the emerging countries like BRIC. It is a known fact that the production and industrial activities involve energy as an essential input. It is one of the key sources of industrialization. As emerging economies keep growing at higher rates leading to rise in income and progression of economy into the industrial stage, the energy need increases significantly due to the emergence of transportation networks, introduction of various factories and other infrastructure requirements that needs sustained sources of energy. This economic transition stage results in much higher energy consumption and subsequently the energy needs increase drastically for these economies. Due to lack of data for manufacturing as a function of total industrial production we consider the share of industrial output in the total GDP. Population growth is another key indicator that is taken into consideration because of the size of population especially in China and India. The size of population coupled with rise in GDP growth and higher per capita income creates demand for various products and this leads to increase in energy consumption. The rate of growth of population in these countries is considered. Transportation is a major contributor to energy use. This becomes even more important variable when it is about these three economies which are geographically the largest countries in the world. Locations with high levels of travel, long-distance travel, level of public transportation and the number of total vehicles in the country typically tend to have a very high-energy consumption. Emerging economies are highly populated nations with raising incomes creating the demand for motor vehicles. Added to this, the vast public transport systems of both nations also play a key role. We take into consideration the registered vehicles both commercial & passenger.

The role of energy imports acts as a double edge impact on energy consumption. The increase in energy imports lead to decline in energy consumption if those goods are used to replace the manufactured goods which are produced domestically which consume high energy levels. Thus, imports of these manufacturing goods, by replacing domestic production, would reduce the energy requirements of the country. However, there is also a contrasting argument which states that if the energy imports are also utilized in capital intensive goods production can lead to increase in energy consumption levels adding to the existing production levels in the country. Thus, the net effect of increase in energy imports can be either positive or negative for the developing economies. Similarly, we also take into account the total energy exports if any to see their effects on energy consumption levels. This is because, the developing countries are largely engaged in production of energy and are used for the purpose of exports resulting in increase in energy consumption levels.

The paper includes the variables Gross Fixed Capital Formation to see its impact of investments in capital intensive industries on energy consumption. There is a strong belief that the level of capital intensive projects of infrastructure related projects and in other industrial sectors is leading to increase in energy consumption levels. For example, the GFCF in China as of 2006 stood at over 40% of GDP, which is higher than any international standards. Massive amount is spent on infrastructure, creating transportation and electricity delivery networks which are having a considerable influence on energy consumption in the country. But, this is not similar with India, Russia and Brazil as the GFCF to GDP is the lower compared to that of China. Finally, we also include oil consumption as an important indicator to see its affects on energy consumption levels in BRC economies. This is because, in countries like India and China, which has a huge demand for oil, actually drives the growth of energy usage. This is preciously the reason why there is a drastic increase in energy consumption levels in the post 1990s. Except for the data of registered vehicles, energy intensive imports and exports, which comes from UN Stats common database, the data for rest is taken from World Bank's World Development Indicators (WDI, 2006).

We now turn to some of the specific variables which are included only in either of the equations like financial market variables and Kyoto Protocol agreements. The financial market liberalization is used to examine the effect of sensitivity of firms engaged in energy production towards the liberalization process. This should eventually lead to increase of investments by these firms in these emerging markets. Here, the financial liberalization measures the whether the economy has engaged in relaxing the rules and regulations related to private and foreign investments and do not tell us the quality of investments. Thus, we take the value "0" for pre liberalization period and take the value “1” for post liberalization period. We also include two financial market variables namely, Stock Market capitalization and value added. We use the market capitalization ratio as one of the variables to measure for quality of financial liberalization. Many researchers in economic literature also used the market capitalization ratio as an indicator of stock market development under the assumption that stock market size is positively correlated with the ability to mobilize capital and diversify risk. Thus, we should see a positive affect of higher stock market capitalization towards emissions in emerging economies. The value traded actually measures the value of the trading taking place in all the firms listed on stock exchanges. Though there are some drawbacks of this ratio, it is a very good measure of the liquidity position of the stock markets. The major advantage of including this ratio in defining stock market development and quality of financial liberalization is that it complements the market capitalization ratio (Levine and Zerov, 1998). This is because, although a particular stock market may be very huge, there may be a very little trading. This is quite common in countries like India, as there are as many as 23 regional stock exchanges and many do not witness trading at all on few days. Thus, this ratio acts as a compliment to market capitalization ratio in providing more accurate information about a country's financial market development process. The data for financial market liberalization comes from Gupta and Yuan (2005) and for the stock market variables, we use the database developed by Beck et al. (2000) and Beck and Al-Hussainy (2006). Lastly, as discussed, we introduce two measures related to Kyoto Protocol agreements to see whether international treaties and agreements related to controlling emissions which in turn puts a cap on levels of energy usage would have any impact on environment quality. Therefore, we introduce the treaties and agreements introduced in Kyoto convention held in Japan. We take the value of “0” for the years before signing the treaty and “1” afterwards. For another variable, we take the value of “0” for the years before ratification of the signed treaty and “1” afterwards. We constructed this dummies based on the information provided by UNFCCC's Kyoto Protocol Background (2007).

c. Threshold Pooled Regression Analysis:

In the third stage, the paper introduces pooled threshold regression analysis which thrives mainly on the interactive dummy variable(s). The idea behind this is to see whether higher economic growth rates are leading to increase in energy consumption levels. Therefore, we include three different levels of GDP growth rates (see scenario – 1 & 2) to check their impact on the energy consumption levels. In the first step, we create a dummy variable for higher GDP growth rates which takes the value of GDP growth rate as one, when the GDP growth rate exceeds 25%, 50% and 75% of their respective average values in separate models otherwise we take the value as zero. In the second step, we interact this dummy values with the actual GDP growth rates. The basic premise is that it takes only the higher GDP growth rates which are above the said values and ignores the years of low growth rates. This would show whether the higher GDP growth rates share a positive relationship or otherwise with the energy consumption levels. The three different levels of GDP growth rates are identified by GDP Interactive Dummy $(ID_{GDP_{it}})$ and is expressed as follows:

$$EC_{it} = \alpha + \beta_1 ID_{GDP_{it}} + \sum_{i=1}^{8} \beta_2 CV_{it} + \varepsilon_{it} \qquad (3)$$

Scenario – 1:

GDP growth rate in year "t" *x* 1 (IF) GDP growth rate is > 50% of its mean value
GDP growth rate in year "t" *x* 1 (IF) GDP growth rate is > 75% of its mean value
GDP growth rate in year "t" *x* 1 (IF) GDP growth rate is > 100% of its mean value

Scenario – 2:

GDP growth rate in year "t" *x* 0 (IF) GDP growth rate is < 50% of its mean value
GDP growth rate in year "t" *x* 0 (IF) GDP growth rate is < 75% of its mean value
GDP growth rate in year "t" *x* 0 (IF) GDP growth rate is < 100% of its mean value

In order to ensure that the model specified is correct and is free from serial correlation, the paper employs Durbin Watson test. We further wanted to ensure that there is indeed no problems associated with serial correlation and hence we also use alternative method called Breusch-Godfrey LM test.

d. Cointegration Test:

To investigate the existence of a long-term relationship between the variables, we explore using cointegration analysis. If the variables that we are using in the study are found to be cointegrated, it will provide statistical evidence for the existence of a long-run relationship. Though, a set of economic series are not stationary, there may exist some linear combination of the variables which exhibit a dynamic equilibrium in the long run (Engle and Granger, 1987). We employ the maximum-likelihood test procedure established by Johansen and Juselius (1990) and Johansen (1991). Specifically, if Y_t is a vector of n stochastic variables, then there exists a p-lag vector auto regression with Gaussian errors of the following form:

$$\Delta Y_t = K + \Gamma_1 \Delta Y_{t-1} + ... + \Gamma_{p-1} \Delta Y_{t-p+1} + \Pi Y_{t-1} + \mu_t \qquad (3)$$

Where, $\Gamma_1, ... \Gamma_{p-1}$ and Π are coefficient matrices, Y_t is a vector of white noise process and K contains all deterministic elements.

The focal point of conducting Johansen's cointegration tests is to determine the rank (r) of matrix Γ_k. In the present application, there are three possible outcomes. First, it can be of full rank, $(r = n)$, which would imply that the variables are stationary processes, which would contradict the earlier finding of non-stationarity. Second, the rank of k can be zero $(r = 0)$, indicating that there is no long-run relationship among the variables. For instance when Γ_k is of either full rank or zero rank, it will be appropriate to estimate the model in either levels or first differences, respectively. Finally, in intermediate case when there is at most r cointegrating vectors $0 \le r \le n$ (i.e., reduced rank), it suggests that there are $(n - r)$ common stochastic trends. The cointegration procedure yields two likelihood ratio test statistics, referred to as maximum eigenvalue $(\lambda_{\max})$ test and the trace test (λ_{trace}). The number of lags used in the vector auto-regression is chosen based on the evidence provided by Akaike's Information Criterion (AIC) and Bayesian (BIC).

e. Granger Causality: VECM

If the two variables specified share a long-run relationship with each other, then the immediate next step is to examine causality, since if two or more variables are cointegrated; there is causality in at least one direction as found by Engel and Granger, (1987). We proceed to determine whether the variable X Granger causes Y and vice-versa, using Vector Error Correction Model (VECM). According to Engle and Granger (1987), if two variables are cointegrated, then a more comprehensive test of causality, which has become known as an Error-Correction Model (ECM) should be adopted. The Vector Error Correction specification restricts the long-run behavior of the endogenous variables to converge to their cointegrating relationships while allowing a wide range of short-run dynamics (Granger Causality). The cointegration term is known as the *error correction* term since the deviation from long-run equilibrium is corrected gradually through a series of partial short-run adjustments. The exact representation of VECM is:

$$\Delta Y_t = \sum_{f=1}^{k-1} \Gamma_1 \Delta Y_{t-f} + \theta\ \varphi\ \Delta Y_{t-k} + \upsilon + \eta_t \qquad (4)$$

where, $\theta\ \varphi\ \Delta Y_{t-k}$ denotes Error Correction Term and 'Δ' stands for first difference. Then first order differenced variables in equation 4 are now stationary and therefore OLS method gives consistent estimates (Enders, 1995).

4. Empirical Results

We now turn towards the empirical results and estimates for equations on CO2 emission and energy consumption for BRIC economies along with USA and Japan. In the first phase, we introduce the results from CO2 emission and energy consumption relationship for all the economies in our study (see table 1). We reported the Fixed Effects (FE) estimations results. As explained before, it may be distinguished between fixed effects and random effects methods of panel data using a Hausman test. In this article, the Hausman test indicated that the fixed effects estimates are consistent with the both null and alternative hypotheses, whereas the random effects estimates are only compatible with the null hypothesis. Therefore, FE method can be applicable.

In the next phase, we examine the energy consumption and economic growth relationship separately for BRIC economies and USA and Japan. This equation involves four models. The model 2, standard model, deals with only BRIC economies and includes all the variables, while model 2A tests for robustness of the standard model (see table 2).

We then present standard model 3 which includes USA and Japan along with BRIC economies. We then introduce model 3A to check for robustness of results (see table 2). In the final phase, we discuss the results derived from threshold pooled regression analysis dealing with higher economic growth and energy consumption. Here, we have six models, three each with only BRIC economies (models 4,5 and 6) reported in table 3 and rest includes USA and Japan (models: 7, 8 and 9) presented in table 4.

We begin with the analysis for model which shows that the economic growth indeed contributes to higher CO2 emissions. This is statistically significant at 10% confidence level. This suggests that the economic growth rate is indeed a major contributor towards degradation in environment quality not only in BRIC economies but also in US and Japan.

Table 1: Results of CO_2 equation function

Dependent Variable: CO2 Emissions

Variables	Standard Model 1
C	-7219253 * (148034)
Economic Growth Rate	25788.1 *** (14354.05)
Energy Imports	153341.6 * (34474.32)
Energy Exports	-8688.81 (15678.96)
Oil Consumption	1157755 * (189096.1)
Kyoto Protocol Ratification	465895.7 * (172388.5)
Kyoto Protocol Signatory	-156657.2 (140247.8)
Share of Industry in GDP	-9957.11 (11648.95)
Energy Consumption	0.7297895 * (0.19686)
Financial Liberalization	-1046642 * (341315.8)
Stock Market Value Added	490670.1 * (171868.0)
Stock Market Capitalization	-995259 ** (426240.1)
R-squared	0.9517
Hausman Test	Chi2(10)= 44.49
Wald Test	Chi2= 1300.72
Total no. observations	72

NOTE: * Significant at 1% confidence level; ** Significant at 5% confidence level *** Significant at 10% confidence level.

The highest impact on CO2 variable is made by the energy imports. We find a very strong positive relationship between energy intensive imports and energy consumption. This relationship is statistically significant at 1% confidence level. This proves the idea that the ever increasing energy imports are indeed contributing to a great level of pollution by consuming more energy. This is well explained by the fact that energy imports for all the BRIC economies (excluding Russia) have been growing since the early 1990s. However, there is no statistical significance for energy exports.

As expected, we find the results of oil consumption in line with what we have argued. This is one of the major reasons why there is a rapid surge in energy usage in all the BRIC economies. The same is true in the case if US and Japan. We find a strong positive association with statistical significance at 1%. Similarly, we also find that an energy consumption level is having a greater impact on CO2. Thus, we prove our point that indeed energy consumption is the major indicator which causes CO2 emission. This relation is very strong that it is statistically significant at 1% confidence level.

We now focus on Kyoto protocol agreements. We find the results to be mixed. We find that Kyoto protocol signature has absolutely no statistical significance. This is because mere signing of the teary would not really help or ensure a country to agree for reduction in CO2 emissions. Rather, this is considered to be the first step in the total process. Therefore, it can be viewed as the first step taken to reduce emission, but this necessarily need not lead to any action which can reduce the emissions. There are all BRIC economies, excepting Russia, which have signed the protocol agreement, but have not specified any specific reduction in CO2 emission rates (UNFCCC's Kyoto Protocol Background, 2007). On the other hand, if the country ratifies the protocol then there is an obligation to take some initiations to cut the emissions. We find a positive and statistical significance of this variable with CO2. This is significant at 1% confidence level, giving support to our argument.

Now we focus on financial markets and their role in inflating CO2 emissions. We find that the liberalization process of financial markets has negative sign and is also statistically significant at 1% confidence level. This might be because of the fact that mere opening up of markets might not really lead to increase in investments by firms, rather quality of openness matters.

However, going by the above argument of quality of openness, we find stock market capitalization also bearing a negative sign and is also statistically significant at 5% confidence level. The reason which we can attribute for this negative behavior is that lack of information disclosure about the amount of trading which has taken place in the markets. This is because, stock market capitalization only shows the total value of the shares listed in the market. But, it does not speak about the number of stocks traded is and the value of those traded stocks (Levine and Zerov, 1998). Surely, this is misleading. Thus, though it is a better indicator over simple financial liberalization dummy, it still has drawbacks of its own as highlighted. But, this argument is nullified, as we find much robust statistical relationship between stock market value added and CO2 emissions only to prove that indeed quality of financial liberalization matters. One key reason why we have included this ratio is that it acts as a compliment to market capitalization ratio in providing more accurate information about a country's financial market development process. So we find a very strong positive relation which is statistically significant at 1% confidence level.

Table 2: Panel Data Results of Energy Consumption

Dependent Variable: Log(Energy Consumption)

Variables	Standard Model MODEL - 2	Robustness Check MODEL – 2A	Standard Model MODEL - 3	Robustness Check MODEL – 3A
C	1.949527 * (0.3692)	1.655679 * (0.3622)	1.245597 * (0.3209)	1.085857 * (0.3009)
Economic Growth Rate	0.002785 *** (0.0016)	0.003560 ** (0.0016)	0.004017 * (0.0012)	0.004849 * (0.0012)
Investments	0.006274 ** (0.0026)	0.004089 *** (0.0022)	0.006069 * (0.0021)	0.004714 ** (0.0019)
Share of Industry	-0.001945 ** (0.0008)	-0.001992 ** (0.0007)	-0.002437 ** (0.0009)	-0.002459 * (0.0009)
Rate of Growth of Population	0.054150 ** (0.0246)	0.067299 * (0.0223)	0.014033 (0.0113)	0.011585 (0.0093)
Total Registered Vehicles	3.92E-07 (9.36E-)	3.78E-07 (8.21E-)	-1.90E-07 (2.02E-)	-1.17E-06 ** (4.78E-)
Energy Imports	0.039049 ** (0.0156)	0.026133 *** (0.0142)	0.011333 * (0.0039)	0.010291 * (0.0036)
Energy Exports	0.004764 + (0.0033)	0.006485 ** (0.0025)	0.002717 (0.0025)	0.003838 ** (0.0019)
Energy Production	2.94E-07 * (8.00E-)	2.38E-07 * (7.98E-)	1.36E-07 * (4.49E-)	8.63E-08 ** (4.20E-)
Log (Energy Consumption (t-1))	0.822051 * (0.0331)	0.846928 * (0.0326)	0.891554 * (0.0276)	0.906834 * (0.0262)
Oil Consumption	-----	1.82E-05 ** (7.89E-)	----	1.38E-05 * (5.92E-)
R-squared	0.996211	0.996309	0.995378	0.995427
Adjusted R-squared	0.996024	0.996123	0.995288	0.995333
F-statistic	5349.052	5352.905	11074.98	10640.67
Prob(F-statistic)	0.000000	0.000000	0.000000	0.000000
Durbin-Watson stat	1.752025	2.018356	1.643517	1.638105
Total no. observations	48	48	72	72

NOTE: * Significant at 1% confidence level; ** Significant at 5% confidence level *** Significant at 10% confidence level; + Significant at 15% confidence level. White Heteroskedasticity-Consistent Standard Errors and Covariance are considered.

The results presented in model 2 are as in expected lines, as the economic growth variable exerts a positive correlation with energy consumption. An increase in 1% in GDP growth rate of BRIC economies lead to an increase in 0.28% in energy consumption. This is statistically significant at 10% confidence level. We take a look at the individual effects of GDP growth rates on energy consumption. We find that all the countries exert statistically significant relationship. The growth rates of India, China and Brazil exert a very strong association with energy consumption. Though Russia also enjoys statistical significance, the coefficient value is much lower compared to its counterparts[1].

The interesting point to be noted is the negative association of share of industry in GDP for the BRIC economies. One reason perhaps could be that none of the BRIC economies industry shares in GDP as high as that of China. This apart, we also notice that there is a declining trend reported for industry share in GDP for Russia and Brazil. While, for India, though increased from 23% in 1992 to 26% in 2004, this is much lower compared to its other BRIC counterparts. In the case of China, it increased from 43% in 1992 to 48% in 1996 only to decline to 45% in 2004.

We also find that higher level of investments in BRIC economies is directly affecting the energy consumption. This is positive and statistically significant at 5% confidence level. The investments naturally start growing when there is a boom in economic growth. Thus, the investments led by higher economic growth are exerting pressures on the levels of energy consumption.

We find a very strong positive relationship between energy intensive imports and energy consumption. A 1% increase in energy imports lead to corresponding increase in energy consumption levels by 4% and is statistically significant at 5% confidence level. This is well explained by the fact that energy imports for all the BRIC economies have been growing since the early 1980s. A similar such trend can be observed in the case of energy exports. But, the rate of growth of energy exports is much lower compared to imports. The relationship is weak with 15% confidence level.

We now move towards, other indicators namely, population growth rate and total number of vehicles. We find that the rate of growth of population is positive and is statistical significant at 5% confidence level. This shows that the energy consumption demand is largely driven by the growth of population in BRIC economies, specifically from India, China and Brazil. However, though we find a positive sign for number of vehicles, we could not find any statistical association.

The energy production which is on rise for all the economies has a positive impact on energy consumption levels as it is statistically significant at 1% confidence level. We

[1] The individual coefficient values for India is 99% with 1% confidence level followed by China 70% with 5% confidence level, Brazil with 63% with 5% confidence level and Russia with 22% with 5% confidence level.

also examined whether the previous year's energy consumption level had any impact on the current year levels. We find the result to be positive and extremely robust with statistically significant at 1% confidence level.

In order to check for robustness of the results, in the next model 2A, we introduced oil consumption. We find that indeed our argument holds good as it is positively affecting the energy consumption levels in BRIC economies. We find that it is statistically significant at 5% confidence level.

In the next model 2B[2], we introduce the lagged value of economic growth rate. We find that previous year's economic growth do not make any impact on energy consumption levels. But the most important thing in these robustness check models is that results related to standard model are found to extremely robust as the signs and significance levels remain unchanged.

In the third model, we introduce USA and Japan along with BRIC economies. We find the results do not change drastically. We still find that economic growth rate is significantly affecting the energy consumption levels. This is statistically significant at 1% confidence level. We also find that the statistical significance of investments in the standard model is 1%, but results related to industry share remain same as was found for BRIC economies. We find negative association which is significant at 5% confidence level.

The other significant aspect of these results is the impact of population growth rate to energy consumption. When we introduce USA and Japan into the model, we find that relation becoming absolutely statistically insignificant. Given the negative rate of growth of population in Japan and a very low rate of growth of population USA is bound to have these affects. We find that energy intensive imports do make a strong impact on energy consumption levels when we bring in Japan and USA into the model. This is statistically significant at 1% confidence level. But, like previous model, we could not find any relationship with energy exports. But, we find a positive and very strong association of energy production and lagged value of energy consumption, both significant at 1% confidence levels respectively.

[2] The results of 2B model are not reported here. The detailed results are provided upon request.

Introducing oil consumption variable, we find that it is making a positive impact on energy consumption levels. This is statistically significant at 5% confidence level. But, we also find that energy exports turning statistically significant at 5% confidence level. The number of vehicles bearing negative sign and is significant. This is largely due to the fact that there is either stagnant of lower rate of growth of number of registered vehicles in USA and Japan during the study period. In the final model 3B[3], we introduce lagged value of GDP growth rate, we find that it is absolutely insignificant. The adjusted R square values for both models overall goodness of the fit is highly significant. The Durbin Watson statistics show that the models do not suffer from serial correlation.

In table 3 there are three different models capturing the impact of higher GDP growth rates only for BRIC economies. We find that whenever GDP growth rate of respective BRIC economies crossed 50% and 75% of their respective mean values, there is no statistical significance. But, when we introduce GDP growth rate greater than 100% of their respective mean value, we find positive results with statistically significance at 10% confidence level. The results are robust compared to our previous model 3.

[3] The results of 3B model are not reported here. The detailed results are provided upon request.

Table 3: Pooled Threshold regression estimates for BRIC economies

Dependent Variable: Log(Energy Consumption)

Variables	MODEL - 4 Economic Growth rate > 50% of Mean Value	MODEL – 5 Economic Growth rate > 75% of Mean Value	MODEL – 6 Economic Growth rate > 100% of Mean Value
C	2.201954 * (0.4397)	2.042454 * (0.4344)	1.928191 * (0.3931)
Economic Growth Rate	-3.06E-05 (0.0011)	0.001451 (0.0014)	0.003230 *** (0.0018)
Investments	0.008012 * (0.0019)	0.007340 * (0.0019)	0.007607 * (0.0018)
Share of Industry	-0.002381 ** (0.0009)	-0.002348 ** (0.0009)	-0.002458 * (0.0008)
Rate of Growth of Population	0.099990 * (0.0242)	0.102243 * (0.0229)	0.095838 * (0.0223)
Total Registered Vehicles	1.42E-06 *** (9.18E-)	1.39E-06 *** (8.63E-)	1.08E-06 + (7.67E-)
Energy Imports	0.035086 ** (0.0153)	0.028505 *** (0.0159)	0.026772 ** (0.0135)
Energy Exports	0.009332 * (0.0027)	0.009003 * (0.0025)	0.008504 * (0.0026)
Energy Production	3.55E-07 * (8.82E-)	3.36E-07 * (8.79E-)	3.08E-07 * (8.12E-)
Log (Energy Consumption (t-1))	0.791398 * (0.0384)	0.805367 * (0.0378)	0.816284 * (0.0339)
Oil Consumption	8.33E-06 (7.95E-)	1.10E-05 + (7.77E-)	1.16E-05 + (7.68E-)
R-squared	0.997066	0.998087	0.996120
Adjusted R-squared	0.998614	0.998740	0.998682
F-statistic	3958.170	4048.623	4201.630
Prob(F-statistic)	0.000000	0.000000	0.000000
Durbin-Watson stat	2.032311	2.001794	2.073112
Total no. observations	48	48	48

NOTE: * Significant at 1% confidence level; ** Significant at 5% confidence level *** Significant at 10% confidence level; + Significant at 15% confidence level. White Heteroskedasticity-Consistent Standard Errors and Covariance are considered.

Therefore we argue that higher economic growth rates are associated with higher levels of energy consumption. Based on this, the GDP growth rate in usual study period explains 0.28% positive increase in energy consumption levels. When we introduced the GDP growth greater than 50% and 75% of mean value, we find no statistical significance. But, we find that the coefficient value of GDP growth greater than 100% of mean value is 0.32%, which in fact is higher than the coefficient value in standard model 2. This shows that whenever the GDP growth rate exceeds their mean value by 100%, its effect on energy consumption increases.

We now discuss our final model, wherein we also include USA and Japan into the pooled threshold regression analysis to find if there is any variation in the results observed earlier. The results are quite different to that of the earlier model. When we introduce two new countries into the model viz., USA and Japan, we find that GDP growth rate at all levels is positive and significant at 1% confidence level. This proves that when we control for highly developed countries like USA and Japan in the model, the results change, meaning the findings are sensitive to the sample size.

Table 4: Pooled Threshold regression estimates for entire sample

Dependent Variable: Log(Energy Consumption)

Variables	MODEL - 7 Economic Growth rate > 50% of Mean Value	MODEL – 8 Economic Growth rate > 75% of Mean Value	MODEL – 9 Economic Growth rate > 100% of Mean Value
C	1.454842 * (0.3627)	1.304477 * (0.3549)	1.269866 * (0.3322)
Economic Growth Rate	0.002159 ** (0.0010)	0.003597 * (0.0013)	0.006325 * (0.0020)
Investments	0.009170 * (0.0019)	0.002704 + (0.0019)	0.008916 * (0.0017)
Share of Industry	-0.002969 ** (0.0011)	-0.003263 * (0.0012)	-0.003080 * (0.0010)
Rate of Growth of Population	0.028858 ** (0.0121)	-0.030952 *** (0.0184)	0.034598 * (0.0103)
Total Registered Vehicles	-3.48E-07 (4.65E-)	-1.15E-07 (6.75E-)	-6.37E-07 + (4.45E-)
Energy Imports	0.013900 * (0.0045)	2.19E-07 + (1.64E-)	0.012832 * (0.0040)
Energy Exports	0.004717 + (0.0032)	-3.56E-07 ** (1.54E-)	0.004524 *** (0.0027)
Energy Production	1.71E-07 * (5.05E-)	2.17E-07 * (7.12E-)	1.44E-07 * (4.62E-)
Log (Energy Consumption (t-1))	0.868747 * (0.0307)	0.902249 * (0.0251)	0.884097 * (0.0281)
Oil Consumption	1.65E-06 (6.35E-)	-1.31E-05 + (9.05E-)	5.74E-06 (5.98E-)
R-squared	0.995153	0.995185	0.998258
Adjusted R-squared	0.995014	0.996051	0.998137
F-statistic	7194.912	7476.898	8216.807
Prob(F-statistic)	0.000000	0.000000	0.000000
Durbin-Watson stat	1.589257	1.501027	1.704111
Total no. observations	72	72	72

NOTE: * Significant at 1% confidence level; ** Significant at 5% confidence level *** Significant at 10% confidence level; + Significant at 15% confidence level. White Heteroskedasticity-Consistent Standard Errors & Covariance are considered.

We find that the GDP growth greater than 50% of their respective mean values has a lower coefficient value compared to the actual GDP growth mentioned in the standard model 3. Whenever the GDP growth rates were above 50% of their means values we find that its impact on energy consumption is 0.22% compared to 0.40% of the actual GDP growth of standard model 3 (table 4). The same can be found for GDP growth rate above 75% of their mean values. But, when we introduce GDP growth rates higher than 100% of their mean value, we find that its coefficient value of 0.63% is much higher than the coefficient value presented in standard model 3. We find that the results of all other variables included in both the models are similar to that of the model 3 discussed earlier. The adjusted R square values for all models range stood at 99% which indicates that the overall goodness of the fit is highly significant. The Durbin Watson statistics also show that none suffer from serial correlation.

We now proceed to apply cointegration tests[4] between CO2 – Energy Consumption and Economic Development - Energy Consumption to detect any possible long-run equilibrium relation between the series for BRIC countries. The cointegration test is the statistical implication of the existence of a long - run relationship between economic variables. The test stipulates that if variables are integrated of the same order, a linear combination of the variables will also be integrated of that same order.

[4] One must note that for cointegration, our dataset increase the number of years for CO2, Economic Development and Energy Consumption from 1970 to 2005.

Table 5: Johansen Cointegration Test for CO2 & Energy Consumption

Country	Equations	Trace Statistic	Critical Value at 5%	Critical Value at 1%	Max –Eigen Statistic	Critical Value at 5%	Critical Value at 1%
Brazil	None	15.43499	15.41 *	20.04	8.782496	14.07 *	18.63
	At most 1	6.652494	3.76 *	6.65	6.652494	3.76 *	6.65
Russia	None	27.35696	15.41 *	20.04 **	22.44670	14.07 *	18.63 **
	At most 1	4.910257	3.76 *	6.65	4.910257	3.76 *	6.65
India	None	18.87460	15.41 *	20.04	14.82855	14.07 *	18.63
	At most 1	4.046047	3.76 *	6.65	4.046047	3.76 *	6.65
China	None	34.67281	15.41 *	20.04 **	24.10295	14.07 *	18.63 **
	At most 1	10.56986	3.76 *	6.65 **	10.56986	3.76 *	6.65 **
Observations	32						
Lags Interval (in first differences)	1 to 1						

Note: * Indicates cointegrating equation(s) at the 5% level; ** Indicates cointegrating equation(s) at the 1% level. Linear deterministic trend is considered.

The null of no cointegrating vector can be rejected for all BRIC countries (see Tables 5) as the empirical findings reinforce the conclusions about the presence of long run relationship and the existence of a linear combination between CO2 and energy consumption. We also found that there are two cointegrating equations for all most all the countries, exception being Brazil and India. This leads to a conclusion that there exists very strong long run equilibrium relationship between CO2 and energy consumption.

Once we confirm that there is a presence of long run relationship between CO2 and energy consumption, in the next step we proceed with the cointegration analysis for energy consumption and economic development.

Table 6: Johansen Cointegration Test for Energy Consumption & Economic Development

Country	Equations	Trace Statistic	Critical Value at 5%	Critical Value at 1%	Max –Eigen Statistic	Critical Value at 5%	Critical Value at 1%
Brazil	None	15.50641	15.41 *	20.04	9.615369	14.07	18.63
	At most 1	5.891044	3.76 *	6.65	5.891044	3.76 *	6.65
Russia	None	24.99580	15.41 *	20.04 *	21.59137	14.07 *	18.63
	At most 1	3.404431	3.76 *	6.65	3.404431	3.76	6.65
India	None	17.32465	15.41 *	20.04	17.27031	14.07 *	18.63
	At most 1	0.054340	3.76	6.65	0.054340	3.76	6.65
China	None	9.444051	15.41	20.04	9.246200	14.07	18.63
	At most 1	0.197851	3.76	6.65	0.197851	3.76	6.65
Observations	32						
Lags Interval (in first differences)	1 to 1						

Note: * Indicates cointegrating equation(s) at the 5% level; ** Indicates cointegrating equation(s) at the 1% level. Linear deterministic trend is considered.

In this case the null of no cointegrating vector cannot be rejected for all countries excepting China (Tables 6). For China we do not find a long run equilibrium relationship between energy consumption and economic growth. We went ahead in using around 10 lags but still we could not find any long run association. However, for other countries, we find atleast one cointegrating equation either statistically significant at 5% and/or 1% confidence level. We found that both methods, trace test and max-eiganvalue test show atleast one cointegrating equation for Brazil, Russia and India, but none for China. The empirical findings conclude a strong presence of long run relationship and the linear combination between CO2 and energy consumption for all the BRIC economies. But, the same is absent in the case of China when it comes to Energy Consumption and Economic Development relationship.

We now shift our focus towards estimating the short run relationship of those combinations in which we have found long run equilibrium and linear combinations. For this purpose, we use Vector Error Correction Model (VECM) as discussed earlier. This model is useful in restricting the long-run behavior of the endogenous variables to converge to their cointegrating relationships while allowing a wide range of short-run dynamics (Granger Causality). Thus, it foresees if there is any deviation from long-run equilibrium, then it is rectified gradually through a series of partial short-run adjustments.

In the table 7, we take into account the equation relating to CO2 and energy consumption for BRIC countries.

Table 7: VECM for CO2 & Energy Consumption

Countries	Variables	Constant	CointEq1	D(CO2(-1))	D (Energy Consumption(-1))
Brazil	CO2 (-1)	-53.02445 (1486.45)	-0.688724 * (0.24646)	0.137703 (0.27300)	-0.804176 (0.65575)
	Energy Consumption (-1)	296.5997 (577.441)	-0.250313 * (0.09574)	0.140682 (0.10605)	-0.323592 (0.25474)
Russia	CO2 (-1)	-1964.867 (12675.2)	0.513114 * (0.54385)	-0.851993 (0.37095)	1.420745 (1.11152)
	Energy Consumption (-1)	-932.9997 (3282.23)	0.488982 (0.14083)	-0.248069 (0.09606)	0.189665 (0.28783)
India	CO2 (-1)	1784.912 (2577.32)	-0.719663 * (0.33359)	-0.360088 (0.16027)	1.055197 (1.06086)
	Energy Consumption (-1)	596.7519 (805.059)	0.182910 * (0.10420)	-0.088303 (0.05006)	-0.005136 (0.33137)
China	CO2 (-1)	2600.567 (18870.0)	-0.589748 * (0.24209)	0.907249 (0.24016)	-0.448615 (0.50980)
	Energy Consumption (-1)	8270.292 (6459.42)	0.193185 * (0.08287)	0.047532 (0.08221)	0.246731 (0.17451)
Observations	32				
Lags interval (in first differences)	1 to 1				

NOTE: * Significant at 5% confidence level

The empirical findings for BRIC countries suggest two different things. Firstly, we find that there is a significant short-run relationship between the two for all countries in the sample. This relationship is statistically significant at 5% confidence level. Second, excepting for Russia, for rest of the countries, we find bi-directional causality. For Russia, we find uni-directional causal relationship flowing from energy consumption to CO2, which means, that the later is influencing the former and it is not the other way round. These results are again consistent to the cointegration results in which we found two cointegrating equations for all countries. Thus from the Granger causality results (Vector Error Correction Model*)*, it is evident that there is a uni-directional Granger-causality for Russia and bi-directional causality for rest of the countries. Hence, it suggests that overall energy consumption and CO2 are strongly correlated.

We now take a look at equation relating to energy consumption and economic development for Brazil, Russia and India. We exclude China because we did not find any long run relationship between energy consumption & economic development.

Table 8: VECM for Energy Consumption & Economic Development

Countries	Variables	Constant	Coint.Eq1	D (Energy Consumption(-1))	D (Economic Development (-1)
Brazil	Energy Consumption (-1)	119.7854 (552.473)	0.179798 (0.18567)	0.162178 (0.29049)	-13.82528 (7.36798)
	Economic Development(-1)	-4.399451 (18.6088)	0.018257 * (0.00625)	0.008566 (0.00978)	-0.400055 (0.24817)
Russia	Energy Consumption (-1)	-774.6795 (3355.34)	-0.159044 * (0.06883)	-0.392512 (0.14533)	-12.37936 (3.84900)
	Economic Development(-1)	0.725840 (170.825)	0.011717 * (0.00350)	0.003394 (0.00740)	-0.068590 (0.19596)
India	Energy Consumption (-1)	1027.951 (726.135)	-1.043784 * (0.23611)	-0.016881 (0.16967)	-94.60456 (50.0674)
	Economic Development(-1)	3.520862 (2.69468)	0.000328 (0.00088)	-8.18E-05 (0.00063)	0.551026 (0.18580)
Observations	32				
Lags interval (in first differences)	1 to 1				

NOTE: * Significant at 5% confidence level

The empirical findings show that there is a uni-directional causal relation for Brazil and India and bi-directional relation for Russia. The findings are statistically significant at 5% confidence level. The interesting aspects of these findings are that for the first model in VECM, we find bi-directional causality for Brazil and India and Uni-directional causality for Russia. In the second model, we find the casual relations have turned exactly opposite to first model. The Granger causality results here show that there is no bi-directional causality for both Brazil and India. But there is definitely uni-directional causality between economic development and energy consumption. Hence, it confirms the contribution of economic growth towards energy consumption levels. These results are consistent with our findings in our earlier models 1 to 6.

5. Summary and Conclusion

While the existing empirical studies have focused on the effects of economic growth and trade on environmental degradation, this work adopted a new approach to the study of environment quality degradation and economic growth by examining BRIC economies to show that the higher levels of growth led by greater domestic demand in creating imbalances in environment. By doing so, we capture Russia, Which is one of the largest energy consumer and supplier, was ignored by many studies.

By taking into account various environmental, macro economic, financial variables along with dummy indicators proxied for Kyoto Protocol treaties, this paper examines the effects of energy consumption on CO2 emission leading to environment degradation in BRIC economies. Also examined is the role played by the domestic demand, dependence on energy and investment activities in these countries on the levels of energy consumption. After finding strong evidences, the study extended in a different approach to see at what higher levels of economic growth the energy consumption does gets effected.

The results suggest that indeed growth in energy consumption levels is having an impact on the CO2 emission in BRIC countries. The high levels of energy consumption are driven by rapid economic growth, international trade in energy intensive goods, along with rate of growth in domestic demand and registered vehicles. This suggests that too much of economic growth is too bad for environmental quality. The results are found to be robust at all different levels. We then proceeded with controlling for two developed countries, USA and Japan. The results are no similar and are very robust.

After finding these evidences, we went on to examine the possible long run effects between CO2, Energy consumption and economic growth and development by introducing cointegration test followed by casualty analysis using Vector Error Correction Method. The results find long run equilibrium and causal association between CO2 and energy consumption levels for all the countries. But, the same could not be found for China in the case of energy consumption levels and economic growth and development.

The one important thing perhaps is that the cut in energy consumption levels is not possible because of its negative effect on growth. But surely, the fast emergining economies like India, China and Brazil which are very highly dependent in energy usage and are the largest energy consumers can look forward to cut down the rate at which they are growing, which can lead to restoration in environment imbalances in years to come. There is also a huge scope to carry forward this research study further by looking at the aspects as highlighted by Stern (2004) related to analysis of the proximate factors driving changes in pollution emissions, energy efficiency, decomposition of sulfur emissions which requires in detailed sectoral examination which could be helpful for the policy makers in both these countries to frame an inclusive environment quality led growth policies in the years to come.

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ANNEXURES

Annexure – 1: Variables Description and data sources

Research Variable	Indicators	Data Source
a. Dependent Variables		
Environment Disturbances - Emissions	CO2 Emission in Kilo Tons tonnes oil equivalent	WDI
Energy Consumption	Energy Use in Kilo tonnes oil equivalent per country	WDI
b. Independent Variables		
c. i. Macroeconomic & Energy Variables		
Growth of market size	ΔGDP/GDP per country	WDI
Industrialization	Share of Industrial Output in GDP per country	WDI
Population	Rate of Growth of Population per country	WDI
Registered Vehicles	Registered vehicles (both commercial & passenger) in 1000s	UN Statistics
Energy Imports	Share of Total Energy Imports/GDP	UN Statistics
Energy Exports	Share of Total Energy Exports/GDP	UN Statistics
Gross Fixed Capital Formation	GFCF as percentage of GDP	WDI
Oil Consumption	Oil consumption in barrels oil equivalent per country	WDI
d. ii. Financial Variables		
Initiation of Financial Liberalization process	The value "0" for pre liberalization period and take the value "1" for post liberalization period.	Nandini Gupta & Kathy Yuan, 2005
Stock Market Capitalization	Total value of all the listed shares / GDP	Thorsten Beck & Ed Al-Hussainy, 2006
Stock Market Value Traded	Total value addition of stocks traded in market / GDP	Thorsten Beck & Ed Al-Hussainy, 2006
b. iii. Kyoto Protocol Agreement Variables		
Signatory *Ratification*	*Takes the value of "0" for the years before signing the treaty and "1" afterwards.* *Takes the value of "0" for the years before ratification of the signed treaty and "1" afterwards.*	UNFCCC's Kyoto Protocol Background document, 2007

Note: WDI: World Development Indicators 2006; World Bank. & UN Stats: UN Statistical database 2006.

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