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URBANIZATION AND TEMPERATURE CHANGE- ACCOUNTING FOR INTERNATIONAL DIFFERENCES FROM BRICS

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ABSTRACT

Urban induced industrialization, energy consumption, carbon emission and rising percapita automobile consumption have impelled society to brace for the heat wave like conditions. Over last 50 years (1956-2005), average annual temperature worldwide has been increased by 0.13 C degrees. Post 2005 period has even faced some unprecedented heat wave conditions across the globe starting from Europe in 2003, Greece in 2006, North America, 2006, India in 2010, 2013 and 2015, Australia in 2012. In this context, this paper empirically examines the importance of such unsystematic urbanization with respect to annual temperature change in case of so-called BRICS economies. For this we have collected data ranging from 1980 to 2012 for five economies namely Brazil, Russia, India, China and South Africa. Data w.r.t annual temperature, urbanization, energy consumption, carbon emission and foreign direct investment are mainly collected from World Bank, EIA and UNCTAD databases. In our empirical setup, we have employed Bayer-Hanck cointegration and different structural break tests. Our long run cointegration result shows that both pollution and annual temperature changes are well cointegrated and robust enough to capture the trend of global warming and environmental changes in an economy. Further, the evidence of structural break tests in forms of Zivot-Andrews Unit Root test and Gregory-Hansen cointegration tests are applied to ensure the breakpoint. It captures the condition of relative unsustainability from the year, when urbanization has exerted significant effect upon the environmental indicators and annual temperature variation. Furthermore, we apply chow forecast test to examine the significance of structural breaks in an economy during the period. The result shows that there exists no breakpoint in all these economies except Brazil during 1990-2012 period. The main policy implication emerging out of this study is that there must be the element of sustainability in industrialization and urbanization processes of the developing economies. The developing economies primarily must adopt the short term goal in attaining sustainability in a coordinated manner and switch over to the long term goal later. All our empirical investigations have confirmed that if such unbalanced growth is not controlled, then the effect of global warming on BRICS is quite imminent.

JEL Classifications*:* O18, Q54, O50

Keywords: Urbanization, Structural Break, Cointegration, Global Warming, BRICS

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INTRODUCTION

Urbanization is one of the key factors behind the increasing global temperature. Over the last 50 years (1956- 2005), the annual average temperature of the world has been increased by 0.13 C (IPCC, 2007). Almazroui et al (2013) have found significant relation between temperature increase and urbanization across Saudi Arabia. Increasing urbanization followed by destruction of forests has fueled the mean temperature across the economies. The so called urban heat island emanates from the growing base of urban population and rising perimeter of the urban space. The growth of urban population has resulted in more industrialization, modernization and more per-capita usages of vehicles (Arnfield, 2003). With the global projection of urban population over 65% by 2050, it is being feared that the annual mean temperature may exceed 2 degree centigrade causing extreme weather events, sea level rise, rising greenhouse gas emissions and changes in El Nino events. Tayanc and Toros (1997) have studied effect of the urbanization rate on the temperature changes in four major cities of Turkey and found a significant association between these two.Generally, urbanization affects the climatic aspect in different ways from the rising pollution and concerned environmental consequences like acid rain, habitat loss and other negative externalities. Urbanization is intrinsically interlinked with local pollution, trans-boundary pollution and global warming effects.

Hulme et al, 1994 have discovered such evidence with respect to the East Asian cities in the last half of 20th century owing to the rapid urbanization effect. Economies irrespective of their spatial location, are reeling under the wrath of climate change due to their unsustainable development patterns. Economies in tropics are suffering from rising global sea level crisis and haze problems, while economies in the colder zone are facing the prospects of iceberg melting and reducing winter days. Existing urbanization, development waves in emerging markets and the already depleted atmospheric conditions of the developed west have made the climate change aspects quite unprecedented. In terms of several world reports from WMO, IPCC, World Bank, it has been specified that after USA, both China and India are the highest emitters of carbon and nitrogen oxide to the atmosphere. Moreover, a scientific consensus needs to be established with the undertaking of sustainability in terms of development, modernization and our lifestyle patterns. These five economies constitute 3 billion populations with the combined GDP of 16 trillion dollars; can impact directly to the climate change aspect of the entire globe (Wheeland, 2015).1 In 2008, four BRIC economies contribute one third of total global carbon emission excluding the emissions from the forest destruction and environmentally unsuitable land usage.2 Economic developments in India, China, Brazil and Russia are powered by the prodigious usage of fossil fuels. A series of situations in BRIC economies after 2009 in terms of soot strained streets, acid rain, low visibility in winter, greater concentration of particulate matter in cities and high public health externalities have already reminded us that the climate change has already possessed with greater threats.

CLIMATE CHANGE EVIDENCES IN BRICS

Clearing of forests, renovation and urbanization of coastal zones and establishment of industrial towns have taken place scale to modernize the economy. These phenomena have created huge segment of urban underclass, unemployment, pollution and other environmental degradation in the newly urbanized towns. Continuous growth of urban clusters near the coastal zones of Brazil has made these vulnerable to the extreme weather events. In the eve of pursuing the path of urbanization, Brazil has borne heavy cost of environmental degradation. Marengo, 2006 has specified that 70% of carbon emission from Brazil has born out of the burning of the Amazon forest for the development and industrial purposes. Such conditions have already affected the precipitation and temperature pattern across Brazil Even such climate change has impacted the spatial distribution of crop production and also rural areas.[3] Similarly, Russia has experienced a significant change in temperature variation and in the number of frosty days. According to observations provided by the meteorological network of Roshydromet, the warming in Russia was 1.29°C for the last 100 years (1907–2006), whereas global warming for the same period was 0.74°C according to the IPCC Fourth Assessment Report.[4] Mean warming temperature across Russia was 1.33 C from 1976 to 2006. Climate change scientists discover the disturbing trend of surface warming in Russia, which is 2.5 times faster than the global average since 1978. In last winter of Dec 2015, Moscow has experienced a record high temp of 8.5 c degree, which led to the shutdown of many ski and winter sports businesses.5 Among all the African economies, South Africa is by far more urbanized with more than 50% people living in the urban areas.6 National Development plan of South Africa has called for equipping with the prospects of spatial justice, spatial resilience, spatial quality, spatial efficiency and spatial sustainability to maintain urban growth of future across the South African cities.

THEORETICAL MOTIVATION

As of now, there exists no such defined theoretical model, which could possibly explain the linkage among the urbanization, energy consumption, industrialization and annual temperature change. However, the evidences of urban heat island effect supported by heat wave incidents and heat dome effect are certain supporting facts in establishing the logic behind our study. Elevated summer temperatures from the urban heat islands prop up not only due to the weather specific variations but also by several man made interventions. Several scientific studies like Johnson and Wilson, 2009: Broto and Bulkeley, 2012; Masson et al, 2014 have provided the crux behind the occurrences of urban heat island phenomenon. However, very few economic studies have related this form of climate change to that of urbanization till date (Barrios et al, 2006: Bruckner, 2012, Henderson et al, 2017). This study has drawn few theoretical backing from temperature shock-growth relationship studied by Dell et al (2012). Their results have shown that higher temperatures have negatively influenced the economic growth across poorer nations over the period 1900 to 2006. Further, they have discovered the evidences of reducing agricultural output, industrial output and declining political stability worldwide owing to the higher temperature increase. Considering the set of all these studies, we have framed our analysis by including the variables like urbanization, carbon emission, energy consumption, foreign direct investment and temperature change into the account.

LITERATUE REVIEW

Very few literatures have empirically established the relation between urbanization and temperature changes via the channels of foreign direct investment, carbon emission and primary energy consumption. Scientific study undertaken by Tayanc and Toros (1997) has analyzed relation between urbanization and daily temperature change in four major cities of Turkey over the period 1951 to 1990, indicating that urbanization holds key in terms of rise in daily temperature across the Turkish cities. Chung et al (2004) have studied such a similar trend between mean monthly temperature change and urbanization rate across 14 synoptic stations of South Korea by analyzing data from 1951 to 1980 and 1971 to 2000. Their analysis has found a significantly positive association between urbanization rate and mean monthly temperature change across South Korea in winter times but insignificant relation during warming season.

In one of the earlier researches, Parikh and Shukla (1995) have provided certain key instances of positive association of urbanization with energy use and GHG emission across the developing economies. Halicigolu (2007) have identified the relation between percapita energy use, percapita income growth and openness ratio in Turkey and reported a short and long run bi-directional causality. Sari and Soytas (2009) have studied the relationship among carbon emissions, energy use, income and total employment in five OPEC regions to identify the potentiality of global warming and found that none of the economies are ready to sacrifice growth in lieu of higher carbon emission.

Pao and Tsai (2010) have analyzed dynamic causal relation among the energy consumption, economic growth and pollution in BRIC economies from 1971 to 2005 and have found that the energy consumption exerts positive impact on the pollution and followed the pattern of EKC pattern. Bell et al (2007) have studied the relation between urbanization process and environmental consequences of 50 American cities and found that temperature rise arising out of climate change has led to 0.11% to 0.27% rise in the mortality rate. Zhou et al (2004) have found an increasing association between urbanization and land quality usage across China, implying negative environmental consequence and warming of surface temperature.

EMPIRICAL MODEL

The proposed model is $AP = f\,(URP, PEC, FDI, CO_2)$. (1)

Here the AP refers to the mean annual temperature of the economy. URP refers to the urbanization rate of the economy, which can be captured by the annual urban population growth. PEC refers to the primary energy consumption of the economy, which reflects the entire consumption of the major sources like automobile, industry and other allied sectors. Foreign Direct Investment shows the inflows of foreign investments annually in these economies. CO_2 is the carbon dioxide emission rate of the economy in a year. Though there are other pollutants affecting the atmospheric circulation, still we assume that carbon dioxide is a suitable proxy in capturing the extent of pollution and global warming to a maximum extent. The share of carbon dioxide among the pollutants is higher in the developing economies because of the higher percapita automobile usage and heavy concentration of industrial clusters.

The equation (1) can be expressed in terms of Cobb-Douglas Production function.

$$AP_{it} = URPit^{\alpha}\, PECit^{\beta}\, FDIit^{\gamma}\, CO2_{it}^{\vartheta} \quad (2)$$

Here α, β, γ and ϑ represent the externalities arising out of the urbanization, primary energy consumption, foreign direct investment and carbon dioxide emission respectively. If we take the logarithmic of both sides of above equation (2), then the underlying equation is

$$AP_{it} = \alpha \, URP_{it} + \beta \, PEC_{it} + \gamma \, FDI_{it} + \vartheta \, CO_{2\,it} \qquad (3)$$

Here i represent the economies of BRICS region and t represents the time period from 1980 to 2012.

ECONOMETRIC APPROACH

Here we have estimated the structural break in our dataset. The first step is to examine the unit root test proposed by Zivot and Andrews (2012) to find an unknown structural break in the system. The reason for applying this type of unit root test is to trace the structural break along with the stationarity. The next issue of interest is the testing of structural break in the long run cointegration analysis, which has been addressed in Gregory-Hansen cointegration test (1996). Previous cointegration tests fail to address the problem of cointegration at a specific unknown point in a sample. In many cases the researcher wishes to know that even if the series is cointegrated, still this linear combination has shifted at one unknown point. Being dealt with each of the economy, it is inevitable to find the breakpoint in the long run cointegrating relation among the variables. In order to confirm the long run evidence further, we apply the Bayer-Hanck cointegration test for all five economies to establish the cointegrating relationship. This test combines the probability values of four tests, which can give better robustness to our analysis.

DATA DESCRIPTION

The variables used in this study include carbon dioxide emission (CO_2), urbanization (*URP*), the primary energy consumption (*PEC*), foreign direct investment (*FDI*) and annual temperature *(AP)*. CO_2 is the total carbon dioxide emission from the consumption of energy measured in million metric tons, and *PEC* is the total primary energy consumption measured in quadrillion Btu. We have taken data of the concerned economies from the Energy Information Administration (EIA) database of USA government. FDI has been constructed as the year wise FDI inflows to different destination countries, in US $ million. The year wise FDI inflows data are taken from the United Nations Conference on Trade and Development (UNCTAD) database. Data of urban population are collected from the World Development Indicators (WDI) database. The Annual temperature database is collected from the Climate Change Knowledge Portal of World Bank.

RESULTS AND DISCUSSION
(CORRELATION MATRIX)

	AP	FDI	PEC	COM	URP
AP	1.000	-0.194	0.173	0.439	-0.324
FDI	-0.194	1.000	0.168	-0.380	0.735
PEC	0.173	0.168	1.000	0.797	0.327
COM	0.439	-0.380	0.797	1.000	-0.230
URP	-0.324	0.735	0.327	-0.230	1.000

Source- Author's own compilation

From above table, we find that the correlation between energy consumption and energy consumption is quite high, while the reverse is also true. There exists the negative correlation between average temperature and foreign direct investment, urbanization and carbon dioxide emission and average temperature and urbanization.

DESCRIPTIVE STATISITCS TABLE

Country	Variables	Mean	St.Dev	Max	Min	No of Obs.
Brazil	*FDI*	9.845	0.672	10.881	8.538	33
	PEC	2.457	0.140	2.699	2.214	33
	URP	8.094	0.991	8.227	7.901	33
	COM	0.901	0.133	1.117	0.689	33
	AP	1.388	0.005	1.401	1.375	33
India	*FDI*	3.3001	0.002	3.304	3.297	33
	PEC	6.961	0.518	7.78	6.002	33
	URP	7.896	0.091	8.059	7.745	33
	COM	6.663	0.520	7.513	5.674	33
	AP	1.390	0.005	1.403	1.381	33
Russia	*FDI*	6.297	4.863	10.674	0.000	33
	PEC	2.097	1.564	3.305	0.000	33
	URP	8.021	0.025	8.038	7.896	33
	COM	0.930	0.715	1.546	0.000	33
	AP	0.139	0.084	0.292	0.025	33
S.A	*FDI*	1.133	0.542	1.4	0.000	33
	PEC	0.625	0.091	0.769	0.436	33
	URP	7.322	0.124	7.510	7.114	33
	COM	2.553	0.067	2.69	2.371	33
	AP	1.387	0.007	1.403	1.377	33
China	*FDI*	9.708	2.633	11.521	0.000	33
	PEC	3.490	0.224	3.91	3.158	33
	URP	8.580	0.172	8.846	8.279	33
	COM	1.591	0.230	2.029	1.260	33

	AP	2.300	1.540	3.304	0.000	33
Total Panel	*FDI*	6.057	4.254	11.521	0.000	165
	PEC	3.114	2.262	7.780	0.000	165
	URP	7.983	0.419	8.846	7.114	165
	COM	2.528	2.198	7.513	0.000	165
	AP	1.007	0.550	1.403	0.000	165

Note: Total variables are here converted into logarithmic format. St.Dev refers to the Standard Deviation of the series. No of Obs refers to the observations in time series and panel as well. Max and Min represent the maximum and minimum of each series.

COVARIANCE ANALYSIS TABLE

Covariance **Correlation** **Probability**	**AP**	**FDI**	**PEC**	**COM**	**URP**
AP	0.301158				
	1.000000				
FDI	-0.453859	17.99505			
	-0.194961	1.000000			
	0.0121				
PEC	0.215107	1.613936	5.088686		
	0.173762	0.168658	1.000000		
	0.0256	0.0303			
COM	0.528776	-3.535533	3.941491	4.802533	
	0.439683	-0.380315	0.797301	1.000000	
	0.0000	0.0000	0.0000		
URP	-0.074440	1.305753	0.309531	-0.211354	0.175111
	-0.324154	0.735577	0.327903	-0.230473	1.000000
	0.0000	0.0000	0.0000	0.0029	

ZIVOT-ANDREWS UNIT ROOT TEST

		level	*level*	*level*	*1st Diff.*	*1st Diff.*	*1st Diff.*
Nation	***Variable***	*T stat*	*Break*	*Decision*	*T stat*	*Break*	*Decision*

Brazil	*COM*	-4.655	2002	Unit root	-7.918	1994	stationary
Brazil	*URP*	-5.249	1998	stationary	-2.873	1996	Unit root
Brazil	*PEC*	-4.877	2002	Unit root	-5.578	2001	stationary
Brazil	*FDI*	-3.657	1994	Unit root	-6.786	1987	stationary
Brazil	*AP*	-6.082	1991	stationary	-9.813	1993	stationary
India	*COM*	-4.314	2001	Unit root	-7.838	1996	stationary
India	*URP*	-2.564	1998	Unit root	-9.520	2002	stationary
India	*PEC*	-4.674	2002	Unit root	-6.697	2005	stationary
India	*FDI*	-7.636	2002	stationary	-8.267	1989	stationary
India	*AP*	-7.328	1995	stationary	-8.053	1996	stationary
Russia	*COM*	-55.779	1992	stationary	-7.224	1994	stationary
Russia	*URP*	-3.963	2007	Unit root	-2.436	1990	Unit root
Russia	*PEC*	-104.478	1992	stationary	-7.125	1994	stationary
Russia	*FDI*	-43.648	1992	stationary	-7.040	1994	stationary
Russia	*AP*	-6.242	1990	stationary	-8.199	1993	stationary
S Africa	*COM*	-4.448	1989	Unit root	-7.816	1991	stationary
S Africa	*URP*	-4.180	2000	Unit root	-4.317	2004	Unit root
S Africa	*PEC*	-4.807	1989	Unit root	-8.135	1991	stationary
S Africa	*FDI*	-7.745	1991	stationary	-7.295	1988	stationary
S Africa	*AP*	-5.127	1993	stationary	-7.530	1996	stationary
China	*COM*	-4.472	1997	Unit root	-5.531	2003	stationary

China	*URP*	-2.373	2005	Unit root	-5.155	2001	stationary
China	*PEC*	-4.827	1997	Unit root	-4.960	2003	Unit root
China	*FDI*	-6.754	1985	stationary	-25.093	1986	stationary
China	*AP*	-1.1004	1990	Unit root	-7.554	1992	stationary

Note*: All variables are transformed into the logarithmic forms. The critical values for trend and intercept are -5.57, -5.08, and -4.82 at 1%, 5% and 10% levels of significance respectively. Here, we have compared the t test statistics with the critical values at 5% level of significance.*

An imminent problem with the conventional unit root tests like ADF test, PP test is that they never take into account the structural break phenomenon. Assuming the time of break as exogenous, Perron shows that the power to reject unit root decreases and structural break is often ignored. Zivot and Andrews implement certain variations in Perron's analysis by assuming that the exact point of structural break in data in unknown. Instead a data dependent algorithm is used in Perron's test to determine the point of structural break in the equation. Zivot and Andrews propose three models to deal with. First is the one time change in the level of the time series. Second is the one time change in the slope of the time series. Third is the one time change in the both level and slope of the time series. Looking at the above table, we can find that most of the data in case of all the economies are stationary at the first difference and having the structural breaks at a particular year. Evidence indicates that the series are integrated of order 1. Zivot-Andrews test thus confirms that the test contains one unknown structural break in the series.

(GREGORY-HANSEN COINTEGRATION TEST-AT LAG 2)

Country	Model	ADF*	BREAK	Z_t	Z_a	BREAK	Lag
Brazil	C	-7.72	1991	-7.84	-43.44	1991	2
	C/T	-7.71	1991	-7.84	-43.54	1991	2
	C/S	-5.58	1989	-7.10	-40.33	1991	2
	C/S/T	-7.63	1994	-7.66	-42.62	1994	2
India	C	-5.22	2007	-5.20	-29.81	2007	2
	C/T	-5.63	2003	-5.72	-23.41	2003	2
	C/S	-3.51	2000	-5.81	-32.34	2007	2
	C/S/T	-6.19	2003	-6.38	-35.65	2003	2
Russia	C	-5.93	1991	-6.03	-35.24	1991	2

	C/T	-6.08	1991	-6.18	-36.24	1991	2
	C/S	4.83	1999	-7.55	-41.72	2000	2
	C/S/T	-7.16	2000	-7.15	-40.38	2000	2
S Africa	C	-5.23	2001	-5.32	-30.93	2001	2
	C/T	-5.24	2001	-5.32	-30.97	2001	2
	C/S	-3.64	1986	-5.44	-31.88	1988	2
	C/S/T	-5.14	1989	-5.96	-34.54	1995	2
China	C	-5.83	1984	-5.92	-36.11	1982	2
	C/T	-7.94	1994	-8.06	-44.27	1994	2
	C/S	-4.80	2002	-8.57	-47.46	1994	2
	C/S/T	-9.56	1994	-9.60	-49.09	1994	2

Note- *The lag length was selected using Akaike Information Criterion. The null hypothesis shows existence of no cointegration. Models C, C/T, C/S, C/S/T represent change in level, level and trend, change in regime and regime and trend respectively.*

Here Gregory-Hansen (1996) test results indicate that ADF and Z_t tests reject the null hypothesis of no cointegration at 1%, 5% and 10% levels of significance for all these four models of all these four economies except in case of China's level & trend and regime & trend cases. However, Z_a fails to reject the null hypothesis of no cointegration. Here in the following table, we have given the asymptotic critical values for all these models.

(TABLE OF CRTICAL VALUE OF G-H TEST)

Model	C	C	C	C/T	C/T	C/T	C/S	C/S	C/S	C/S/T	C/S/T	C/S/T
	1%	5%	10%	1%	5%	10%	1%	5%	10%	1%	5%	10%
ADF	-6.05	-5.56	-5.31	-6.36	-5.83	-5.59	-6.92	-6.41	-6.17	-7.31	-6.84	-6.54
Z_t	-6.05	-5.56	-5.31	-6.36	-5.83	-5.59	-6.92	-6.41	-6.17	-7.31	-6.84	-6.54
Z_a	-70.16	-59.40	-54.38	-76.95	-65.44	-60.12	-90.35	-78.52	-75.56	-100.69	-88.69	-82.30

The conventional cointegration tests like Engle and Granger (1987), Johansen and Juselius (1990) do not take into account the structural break aspects in long run relationship. These cointegration tests assume that cointegrating vectors do not vary over time. Gregory-Hansen (1996) proposed cointegration relation based on the structural break by taking into account ADF, Z_α, and Z_t test statistics. The most widely applied tests are the residual based cointegration tests in which null hypothesis of no cointegration is tested against the alternative hypothesis. In many cases the researcher wishes to know that even if the series is cointegrated, still this linear combination has shifted at one unknown point. In such context, the standard test of cointegration seems inappropriate, as they assume that cointegrating vectors are time invariant (Gregory and Hansen, 1992, QED Working Paper). To account for such one endogenous break, G-H tests take into consideration four possible cases- Level Shift (C), Level Shift with Trend (C/T), Regime Shift Where Intercept and Slope coefficients Change (C/S) and Regime Shift Where Intercept, Slope Coefficients and Trend Change (C/S/T). Here Gregory-Hansen (1996) test results indicate that ADF and Z_t tests reject the null hypothesis of no cointegration at 1%, 5% and 10% levels of significance for all these four models of all four economies except in case of China's level & trend and regime & trend cases. However, Z_α fails to reject the null hypothesis of no cointegration. The break dates are automatically chosen by the software. The lag period is selected based on the Akaike information criterion. Here the null hypothesis is stating that there exists no cointegration at break period. If the critical values of all these ADF, Z_α and Z_t statistics are greater than the calculated values, then we reject the null hypothesis of no cointegration. The break dates chosen here are by far coinciding the transition period of each of the economy. In 1984, China's economic reforms and waves of urbanization have been started. Russia's 1991 period has experienced a marked shift in the economic growth and liberalized market regime. India has experienced a great stride in economic growth.

BAYER-HANCK COINTEGRATION TEST

Annual temperature = f (urbanization, fdi, energy consumption, carbon emission)

Country	Lag Structure	EG-JOH	EG-JOH-BO-BDM	COINTEGRATION
Brazil	1	9.205*	32.561*	YES
Brazil	2	12.603*	32.547*	YES
India	1	25.622*	62.463*	YES
India	2	56.981*	79.284*	YES
Russia	1	60.084*	65.541*	YES
Russia	2	57.296*	72.795*	YES
South Africa	1	16.557*	28.217*	YES
South Africa	2	57.385*	80.097*	YES
China	1	56.204*	63.413*	YES

China	2	56.715*	68.033*	YES

Note *– * represents the 5% level of significance. The critical values at 5% level of significance are 10.576 (EG-JOH) and 20.143 (EG-JOH-BO-BDM) respectively (Bayer and Hanck, 2013). Lag length is based on the Akaike Information. EG-JOH test is the combination of two cointegration tests, while EG-JOH-BO-BDM test is the combination of four cointegration tests.*

Engle and Granger (1987) have proposed residual based cointegration. The problem with all these cointegration tests is that they do not provide any unifying conclusion with respect to the long run cointegration. All these cointegration tests prior to B-H test produce conflicting results over their applications. In order to overcome such issue, Bayer and Hanck (2013) have proposed new form of combined cointegration test. They proposed to combine the p values of all cointegration tests with the Fisher's formula

$$EG - J = -2\,[\ln (P_{EG}) + \ln (P_{J})] \quad (4)$$

$$EG\text{-}J\text{-}BO\text{-}BDM = -2\,[(P_{EG}) + \ln (P_{J}) + \ln (P_{BO}) + \ln (P_{BDM})] \quad (5)$$

Here the above test combines P values of Engle and Granger, Johansen, Boswijk and Banerjee-Doladoe-Mestre cointegration tests. As a rule of thumb, the null of no cointegration will be rejected, if the critical values of B-H test are less than the Fisher test statistics. In our cases, at 5% level of significance, we have rejected null hypothesis of no cointegration for all countries except Brazil.

(BAYER-HANCK TEST OF COINTEGRATION)

Carbon emission = f (annual temperature, urbanization, energy consumption, FDI).

Country	Lag Structure	EG-JOH	EG-JOH-BO-BDM	COINTEGRATION
Brazil	1	10.661	35.845	YES
Brazil	2	12.839	20.856	YES
India	1	14.712	16.019	YES
India	2	55.417	62.063	YES
Russia	1	55.394	56.153	YES
Russia	2	55.439	114.964	YES
South Africa	1	10.123	28.304	YES
South Africa	2	56.523	130.206	YES
China	1	56.531	66.626	YES
China	2	57.222	112.884	YES

Note *– here * represents the 5% level of significance. The critical values at 5% level of significance are 10.576 (EG-JOH) and 20.143 (EG-JOH-BO-BDM) respectively (Bayer and Hanck, 2013). Lag length is based on the Akaike Information (Akaike, 1975). EG-JOH test is the combination of two co-integration tests, while EG-JOH-BO-BDM test is the combination of all four cointegration tests.*

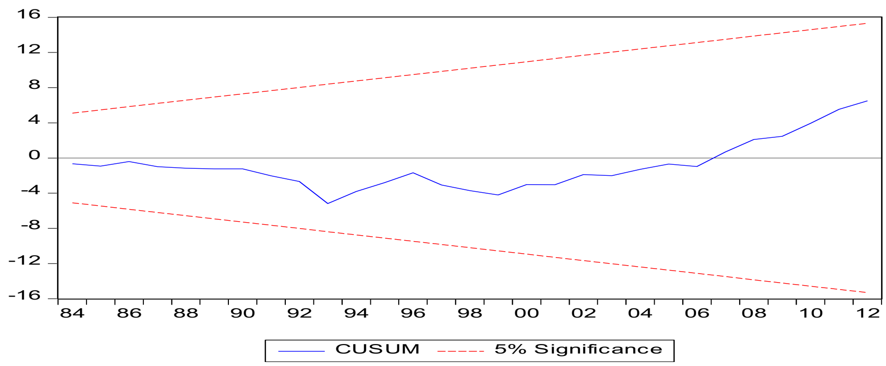
In the above table, we have made carbon dioxide emission as the dependent variable to cross-check the existence of cointegration across the series. In all cases, we have rejected the hypothesis of no cointegration at 5% level of significance for all the economies, as the critical values of B-H test are less than those of Fisher test statistics for all these five economies. It reflects that both pollution and annual temperature changes are robust enough to capture the trend of global warming and environmental changes in an economy.

CHOW FORECAST TEST (FOR DIFFERENT YEARS)

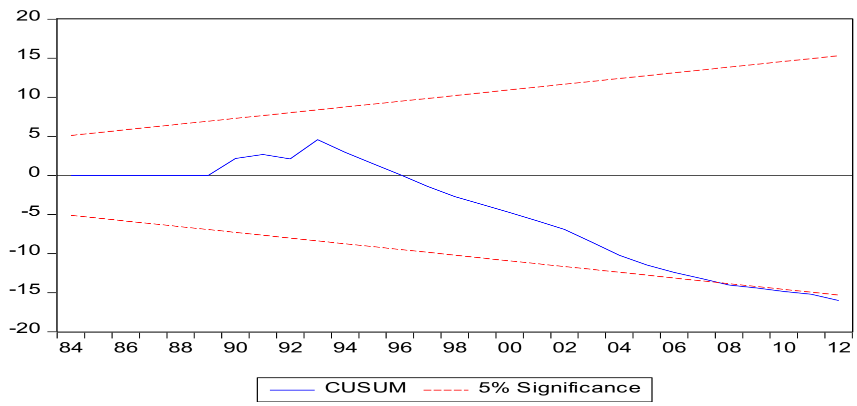
Countries	F statistic	Probability	Log Likelihood	Probability
Brazil (1990-2012)	6.548	0.0134	107.648	0.000
Brazil (2005-12)	1.566	0.194	15.441	0.051
India (1990-2012)	1.416	0.352	61.403	0.000
India (2002-12)	1.140	0.388	17.450	0.095
Russia (1995-12)	0.249	0.995	11.301	0.881
Russia (2004-12)	0.515	0.945	0.879	0.649
S.A (2000-12)	0.593	0.826	12.982	0.449
S.A (2006-12)	0.672	0.709	7.527	0.480
China (1991-2012)	2.155	0.150	67.681	0.000
China (2000-12)	0.732	0.710	15.417	0.282

PLOT OF CUMULATIVE RECURSIVE RESIDUALS

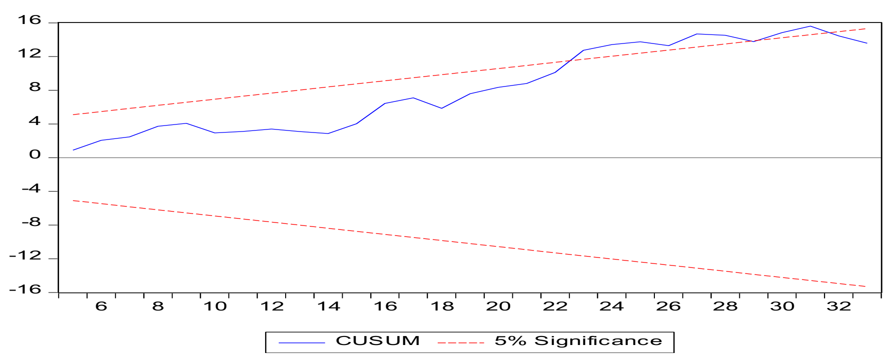
(Brazil)



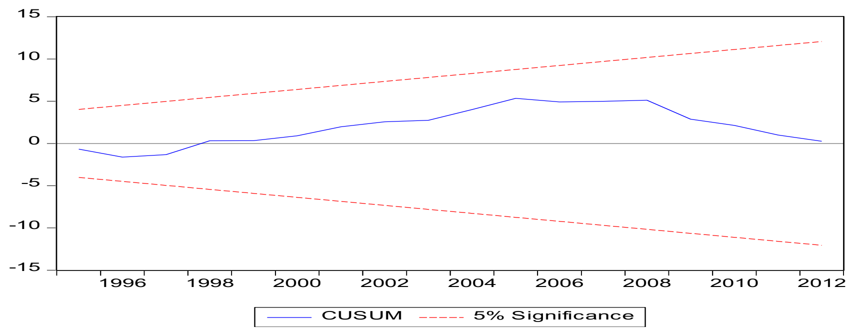
(China)



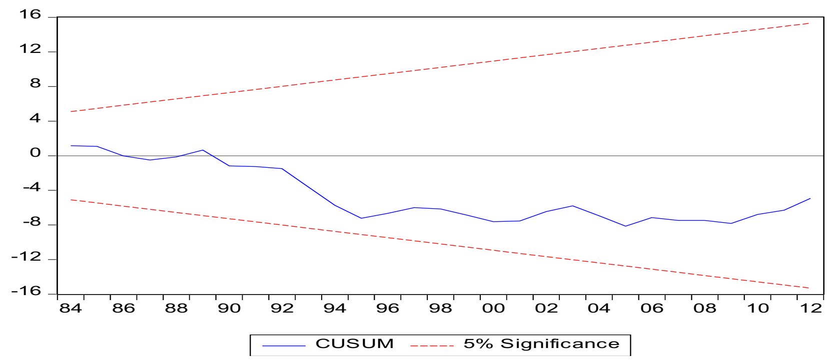
(India)



(Russia)



(South Africa)



The graphical representation of figures shows that the plots of cumulative statistics are well within their critical bounds, implying the stability in the model. Furthermore, we apply chow forecast test to examine the significance of structural breaks in an economy during the period specified in the above table. We find, F statistics from the above table suggests that there is no such break point across the economies within the selected specified time except Brazil in case of 1990-2012.

CONCLUSIONS

The paper contributes to the understanding of the global warming arising out of the unsystematic urbanization in the BRICS economies. Each of the economy after 2000s have faced extreme weather events at various points of the years- drought, monsoon reversal, floods, sea level rise, coastal floods and frequent occurrence of typhoons and tropical storms. Most notable events are the heat waves of 2005, 2010 in Russia, floods of 2015 in Brazil, droughts of 2011, 2014 of India and frequent typhoons of eastern China.

The rapid increase in the levels of urbanization, energy consumption, carbon dioxide emission, annual temperature and foreign direct investment in BRICS has motivated the researcher to explore the relationship between these variables. The Bayer-Hanck cointegration test has already established the long run cointegration between the variables across these economies. Even from the structural break cointegration test, we have obtained break year, which relatively matches the transition period of those economies. The main policy implication emerging from our study is as follows. The industrialization process must be controlled to certain extent in developing economies. There needs a ban on the establishing of industries on the wetland and other sub-urban and forestry areas. Second, more stringent action is needed in terms of controlling the percapita automobile usage in India and China. Some cities (Chennai, Hong Kong, Shanghai, Mumbai, and Kolkata) across Asia have the highest usage of two wheelers in the world. In sum, we do believe that we cannot have the sufficient understanding of long term urban growth unless we understand the evolution of inter-linkage between industrialization and environment.

ENDNOTES

[1]See http://www.theguardian.com/sustainable-business/2015/may/04/brazil-china-russia-india-climate-change-labor-economy-sustainability.
[2]See http://thediplomat.com/2011/11/china-brics-and-the-environment/[3]See "Climate Change and human activities in Brazil with emphasis on Coastal zones" by Carmo and Nunes, 2008, TerrÆ, Vol-3(1), P. 40-45.
[4]See http://www.climatechangepost.com/russia/climate-change/.
[5]See http://www.ibtimes.com/why-russia-warming-more-twice-fast-rest-world-climate-change-experts-raise-concerns-2240034.
[6]See http://www.brookings.edu/blogs/africa-in-focus/posts/2015/12/02-africa-climate-urbanization-sy-goyal.

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