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CO_2 IMPACT ON GDP AND TPES, PANEL DATA ANALYSIS OF BRAZIL, INDIA, CHINA AND SOUTH AFRICA COUNTRIES

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Abstract

This study analyses energy trends for**Brazil, India, China and South Africa** (BICS) countries for the years 1991 to 2015using simple macroeconomic equations calculating per-capita energy consumption, total energy consumption and rate of CO_2 emissions.China holds the first position in CO_2 emission and total energy demand,whereas South Africa has the highest per-capita energy consumption.TheHausman Test recommendsPanel RegressionModel to determine causality between GDP, TPES and CO_2 emissions. The results obtained suggest that GDP and CO_2have a negative relationship, whereas CO_2 have a positive relationship with TPES over time. TheJohanson Co-Integration Test suggests thatvariables are highly co- integrated with each other, and TPESpossessesclosest relationship with the rate ofCO_2emission, followed by GDP toTPES and GDP to CO_2 emission. The Impulse Response Function shows that CO_2 will rise due to GDP and TPES in future, and a positive shock to the TPES will increase GDP, whereas a positive shock to the GDP will not cause TPES to rise until three years.

Keyword: TPES, GDP, Co_2emission, Per capita energy consumption, Total energy consumption.

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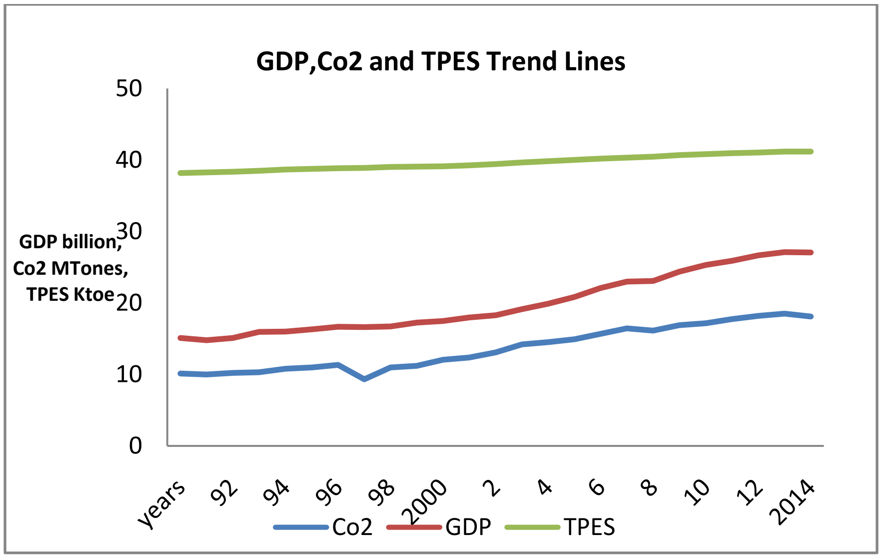
Introduction

The Paris Agreement (November 2016) impetus to curb the rate of emission for future generations particularly focuses on three important factors where each country stipulated to reduce 35% to 30% rate of emission as compared to present emission rate by 2030 and try to reach 40 percent of electricity generation through non-conventional sources by 2030 secondly to increase area of forest cover to absorb 3million tons of CO2 by 2030. Now assume if rate of emission remaining constant as today even though the global temperature will increase beyond 3 degrees by 2030 (where larger proportion of emission is erupting from consumption side 86% and 14% from production side this might be because of outdated technology in consumption side(Montek Ahluwalia, Himanshu Gupta and Nicholas 2016). Advent future will percolate more than 53 percent of the world population in Asia which means half of the emission content will be decided by the Asian countries therefore 39 percent share occupied by oil in primary consumption will reduce by 37 percent by 2020 and East Asia countries (Japan, South Korea, China) will continue their dependence on nuclear sources therefore future energy dimension will be dependent on technological exchange between these countries(Kokichi Ito, Li Zhidong and Ryoichi Komiyama 15-04-2018). By using of non-conventional energies will improve energy efficiency (which is directly dependent on energy intensity ratio, reducing intensity ratio improve efficiency) with fewer environment adversaries and mere foreign dependence(Ilhan Ozturk 2013). But unfortunately enumeration of renewable sources is kept on least priority this might because of less quantitative data and lack of efficient forecasting models unlike in case of conventional sources, Markal linear model (estimates cost and efficiency) and Soft energy Path (suggest alternatives) are efficient modelling to forecast future renewable energy growth (Hélène Connor- Lajambe 2018). The ratio of weight to power in the industrial boiler has decreased more than hundred times since nineteen century but with an increase in income, the rate of intensity has reduced(Galli 1998).

Know imagine India energy sector in 2040? India Vision 2040 aims to answer some precise question. Demand-driven provision of energy at affordable prices, high per capita consumption of electricity and access to clean cooking energy and electricity with universal coverage, low emission and security of supply will characterize the energy parameters of India in 2040 (Al-Muriati 1996). The supply shortage is quite common in many developing countries, especially for commercial energies in general and electricity in particular, which arise due mainly to inappropriate policies and investment decisions. In such cases, consumers may not represent the actual demand due to the existence of unfulfilled or suppressed demand and the market does not clear through the interaction of supply and demand due to interventions in the market (Bhattacharyya March 2009). The National Energy Policy (NEP) aims to chart the way forward to meet the Government’s recent bold announcements in the energy domain. The world is moving away from overwhelming dependence on fossil fuel, and within the fossil fuels, away from coal and oil in favour of gas. With an 88% total share of fossil fuels globally in the primary energy mix in the year 2005, the same fell to 86% in the year 2015(Aayog 2017). The IESS has been used to generate multiple scenarios of the likely energy demand for the country up to the year 2040 on a 5 yearly basis. These have been developed keeping in mind energy efficiency, behavioural changes and elasticity of energy demand to GDP. Energy demand could be brought down over the default scenario by 17% by suitable interventions(Bohi 1981). It has also revealed that even if efforts were stepped up to enhance domestic energy supply, coupled with heroic effort to reduce energy demand, India’s overall primary energy import dependence could still rise to 36-55% by 2040 from 31% in 2012.

Empirical Literature



Trend Chart of CO2, TPES, GDP 1991-15 **Fig A**

Energy plays a very important role in the supply chain as it is both a final good for end-users as well as an input in the production processes of businesses (Sari 2008)**.** The importance of energy draws attention on the relationship between energy consumption and economic activity**.**(Parikh 1991)argued that developing countries contribute less than developed countries to carbon emission and their per capita carbon emission is significantly lower than those of developed nations. 21% and 16% population of the world live in China and India respectively and these two countries need special efforts for any successful reduction in CO emission. As per (Parikh 1991), there have been large shifts in demographic composition in many countries over the past century and are expected to continue changing in the future. India and China are good examples. At the national level, urbanization has been associated with increases in energy use and more carbon emissions. (Alcamo 1998)**,** points out a few models consider urbanization as a determinant of demand for household biomass energy and increasing urbanization in the entire world has significantly increased energy demand and its consumption which in turn has led to higher carbon emissions. Due to the swift expansion of foreign trade and the worsening environment of China, many studies in recent years have focused on this particular country and most of these found a positive correlation between China's foreign trade and its CO2 emissions. (Shui 2006) estimated that about 7% in 1997 and 14% in 2003 of China's CO2 emissions are the results of emissions are the results of producing goods for export to USA. Brazil has become a net exporter of embodied CO2, trade-embodied-CO2 accounts for 11.4% of its total emission. (Foxon 2003) points out some experts have posited that industrial countries have become locked into fossil fuel based energy systems through path dependent processes driven primarily by increasing returns to scale. First industrial revolution in United Kingdom in the eighteenth century and increasing population in all parts of the world led the development of industrial activities and increase in the exploitation of the natural resources in the entire world. Since then there is an increase in the global temperature and this increase has been very high in the past 20th century. This increase in global temperature has led to the problem of global warming. Increase in carbon emission, emission, economic growth, population and consequently more energy consumption are pros and cons for each other. Increase carbon emission due to increased industrial activities, more exploitation of natural resources, increased transport etc. has led to several harmful effects such as increase in overall temperature of the planet, drastic climate change, increased number of flood rate, hurricanes, heat waves and droughts, earthquakes etc. Brazil is the sixth-largest emitter of total greenhouse gases in the world. Russian Federation is the only BRICS country, which registered fall in CO emissions during 1990 to 2011. India with a GDP of 3976.5 billion $ 2005 prices (5.66 % of the world) and population of 1241.5 million (17.84 %) in 2011 is the third largest carbon emitting country in the world. South Africa with a GDP of 489.6 billion $ 2005 prices (0.70 % of the world) and population of 50.6 million (0.73 %) in 2011 is the lowest carbon emitting country among all the BRICS countries (Ahuja 2014)**.** The quest for higher economic growth cannot be detached from the issue of energy security and environmental deterioration. On the one hand, serves as an essential input for economic activity, but on the other hand, extensive use of energy exerts greater pressure on the environment, due to either by-product pollutants or depletion of natural resources. In the context of sustainability, economic development should be achieved while making efforts to preserve the environment so that its utility for future generations is maintained (Managi 2016)**.** China has long been the world's largest producer and consumer of coal and now uses 39 % of the world's total. In 2006, China passed the USA as the world's top CO_2 emitter, with 6.1 billion tons of annual emissions, and by 2008 had already outdistanced the USA by 1.5 billion tons. In July 2010, the International Energy Agency (IEA) announced that China had, in 2009, passed the USA to become the world's largest energy consumer (Michael Kuby 2011)**.** Cities have been one of the most important areas of CO_2 emissions. It is increasingly important to research the effect of urbanization on CO_2 emissions, especially in large emerging and developing economies, due to the indispensable need for understanding the effect of urbanization on CO_2 emissions. Urbanization increases energy consumption and becomes one of the main contributors to CO_2 emissions. China has become the country with the highest CO_2 emissions since 2006. Urbanization level in China increased rapidly from 35.87% in 2000 to 55.61% in 2015 (Gregg 2008). The Kyoto Protocol had been signed in the year 1997 to tackle the effect of global warming. The major feature of the Kyoto Protocol is that it sets binding targets for the 37 industrialised countries and the European community and explores options to reduce Green House Gases (GHGs) emissions to 5.2% lower than the 1990 level during the period 2008-2012. India has tremendous opportunity of generating additional revenue through trading of carbon credits earned. Econometric Model developed in this study tries to address most of the issues that surrounds India's Climate Change Policy (Pravin Agrawal 2010)**.** One straight-forward option to reduce GHG is through the reduction of energy consumption. While the developed countries argue that an international climate change agreement would be meaningless without developing countries like India and China being parties to it, India has maintained that owing to their historical responsibility, the developed nations need to set more ambitious reduction targets before asking the developing countries to do the same. Since India is the third largest GHG producer, it is already facing continuous pressure for reduction in GHG emissions (Ghosh 2010). India is one of the fast-growing economies, growing at a projected rate of 8–9 percent annually. Rapid industrialization over the last two decades has also resulted in the development of infrastructure and increasing use of electricity to cope up with the challenging business and managerial processes. India, the world's fourth largest carbon emitter, is under pressure to cut pollution in the fight against climate change. About 80–90 percent of India's commercial energy requirement is fulfilled by fossil fuels like coal, oil, and gas. While per capita emissions are still low as compared to other developing countries, the rapid growth in information and communication technologies (ICT), more economic activities in turn leads to more productive ventures that gives rise to incomes to go up which implies people demand more energy; it has all resulted in increasing use of energy that causes the exploitation of fossil fuels in generating the required input of electricity, so this cycle of generating electricity from fossil fuels have resulted in increasing emissions of CO2 over a period of time (Krishna Murthy Inumula 2017). The major objectives of the paper are as to examine the trends in carbon emission, total primary energy supply, GDP and population in selected countries. This paper studies the trends in carbon emission, GDP, population and total primary energy supply, in selected nations as well as assesses and impact of GDP, population and TPESon carbon emission in these countries using the secondary data from IEA.

Model

This study compares four emerging economic powers and their energy dimensions (India, China, Brazil and South Africa BICS, starting with three indicators of energy, and then analysingthem through econometric model). BICS countries are compared due to similarities in their demographics, fast economic growths, energy needs, geographical size and their dominance in world economy.

Few equations have beenused initially to depict energy trends of the past 25 years seen in BICS countries by calculating five-yearly performances of each country. Popular macroeconomics equations observe the countries' performances as follows:

a. Per- Capita Energy Consumption

Per-capita Total Energy Consumption/ Population

b. Rate of CO2 Emission

CO2 Emission Total CO2 Emission/GDP

c. Total Demand

Total energy demand = Per-capita X Total Population.

The βi coefficients are the long run elasticity estimator of CO_2 emission with respect to GDP and TPES (all the three variables are converted into per capita level after dividing them by population of same year). If $\beta > 1$, it indicates that growth of CO_2 is greater than the two variables.

The study is divided in two segments; the first section involves a Panel Data Unit Root Test to check stationarity > Co-integration Test for checking the integration among variables > Granger Causality Test to check lag dependence. The latter section involves Panel Regression to analyse long term elasticity of variables > Impulse Response Function for future behaviour.

$$C_{it} = \alpha + \beta\Sigma x_{it} + \beta_1\Sigma x_{it} + \mu_{it}$$

Where

i = number of variables 1...3

t = time periods 1...15 years

α = constant or intercept

Y = CO2 Emission

x = GDP, Billion

x1 = Total primary energy supply, Ktoe

μi = (Vit - Uit) Residual or Error term,

Uit is the overall residual and Vit is independently distributed variances

Data

The data is compiled from International Energy Agency (IEA), which show GDP in millions, CO_2 in metric tonnes emission (taken from indicator statistics, IEA), and total primary energy supply (TPES) (from balance statistics starting from 1991 to 2015). All the three variables are presented in the per capita form, because each variable is divided by population growth in billions.

<u>Panel Data Unit Root Test Results</u> 1.1at 95% significance level

Liven Lin Chu Test H_0: Panel Unit Root H_A: Panal Stationary

Hadri LM Test H_0: Panel Stationary H_A: Panal Unit Root

	Variable	P. Value	Ho	Stationary
Liven Lin Chu Test				
	GDP(second difference)	0.00	Reject	Yes
	TPES (first difference)	.05	Reject	Yes

	CO2 (first difference)	.01	Reject	Yes
Hadri LM Test	GDP(second difference)	0.77	Accept	Yes
	TPES (first difference)	.28	Accept	Yes
	CO2 (first difference)	.86	Accept	Yes

The Panel Data Unit Root Test is performed to check the stationarity of variables,because it is observed that non-stationary series may lead to a spurious regression (discovered by Yule, May 2009).Therefore, two different tests are used; the Levin Lin Chu and Hadri LM tests to detect the stationarity.**Levin et al. (2002, LLC) initiated research on the Panel Unit Root with heterogeneous dynamics, fixed effects, and an individual-specific determinant trend, where they assumed the presence of a homogeneous autoregressive root,** and the **Hadri**Lagrange Multiplier (2000)**test** where the null hypothesis is stationary. This is the generalisation of the KPSS fluctuation test for time series. Both tests indicated stationarity at first difference, except GDP which showed stationarity at second difference.

Johanson Co-Integration test results. 1.2

At 95% significance level.

H_0: 0=no integration among variable, 1= integration among variables

H_A: Integration among variables

Number of observation: 23

Guideline: If TC > CV, reject Null H_o

If TC < CV, accept Null H_o

Rank	Eigen value	Trace value	5% critical level
0		*24.63*	29.68
1	*.441*	*11.24*	15.41
2	*.318*	*2.42*	3.76

Recent literature has focused on the examination of co-integration in a panel setting. We use the following types of panel co-integration tests:**the Johansen Test, named after Søren Johansen, is a procedure for testing co integration of several in 1995.**

Johansen Co-integration Test results shows that there is one co-integration among the variables, and rejected zero-co integration, which implies that all three variable are dependent on each other, which can be a bidirectional or unidirectional relationship, to be observed by IFR latter.

Granger causalityTest. 1 .3.

Hence: H_0: Lagged (2lag) excluded does not cause the equation value.

H_A: 2 Lag excluded cause equation value

	Equation	Excluded	Chi Value	P>Chi	Ho
Lag 2 A	CO2	GDP	3.9	0.69	Accept
	CO2	**TPES**	**10.9**	**0.02**	**Reject**
	GDP	CO2	2.4	0.29	Accept
	GDP	TPES	3.6	0.15	Accept
	TPES	CO2	3.3	0.64	Accept
	TPES	GDP	13.3	0.19	Accept
Lag 3 B	CO2	GDP	5.4	0.27	Accept
	CO2	TPES	11.9	0.01	Accept
	GDP	CO2	3.5	0.48	Accept
	GDP	TPES	12.8	0.30	Accept
	TPES	**GDP**	**40.2**	**0.004**	**Reject**
	TPES	CO2	2.7	0.33	Accept
Lag 5 C	CO2	TPES	56.44	0.00	Reject
	CO2	**GDP**	**31.6**	**0.01**	**Reject**
	GDP	CO2	6.3	0.27	Reject
	GDP	TPES	20.9	0.001	Reject
	TPES	CO2	15.2	0.01	Reject
	TPES	GDP	98.6	0.00	Reject

Granger (1998) mentioned that if the series were co-integratedit can determine the direction of causality. In this section according to our co-integration test results lag dependence is observed, GC test is significant from 2 degree of lag to 5 degree of lag. Therefore results suggest that TPES cause CO_2 with 2 time lag followed by GDP causes TPES with 3 time lag where GDP cause CO_2 emission having least 5 time lag causality.

Hausman Tests results:

Before proceeding to Hausman test, LM test is performed, where Ho: Accept OLS Polled Model. and HA: Accept Fixed Effect Model. Therefore the prob >chi = 0.02. Hence, we reject the Null Ho. The Breusch-Pagan (BP) test is one of the most common tests for heteroskedasticity. It begins by allowing the heteroskedasticity process to be a function of one or more of your independent variables, and it is usually applied by assuming that heteroskedasticity may be a linear function of all the independent variables in the model. This assumption can be expressed as

$$\varepsilon_i^2 = \alpha_0 + \alpha_1 X_{i1} + \ldots + \alpha_p X_{ip} + u_i$$

Hausman tests (Hausman 1978) are tests for econometric model misspecification based on a comparison of two different estimators of the model parameters. Hausman involves comparison of two different estimators for the parameters of a Panel Data Regression Model. Specifically, it is well known that both the "random effects" and the "fixed effects" panel estimators are consistent under the assumption that the model is correctly specified and that (among other things) the repressors are independent of the "individual-specific effects" (the "random effects" assumption).

$$\text{H}= (\boldsymbol{\beta re} - \boldsymbol{\beta fe}'(\boldsymbol{v}(\boldsymbol{\beta fe}) - \boldsymbol{v}(\boldsymbol{\beta fe}))(\boldsymbol{\beta re} - \boldsymbol{\beta fe}) \qquad 1.4$$

Equation 1 Hausman test compares co-variance of fixed and random effect model

1. H_0**:** Accept random effect model. 2. H_A**:** Accept fixed effect model.

Prob>Chi : 0.01

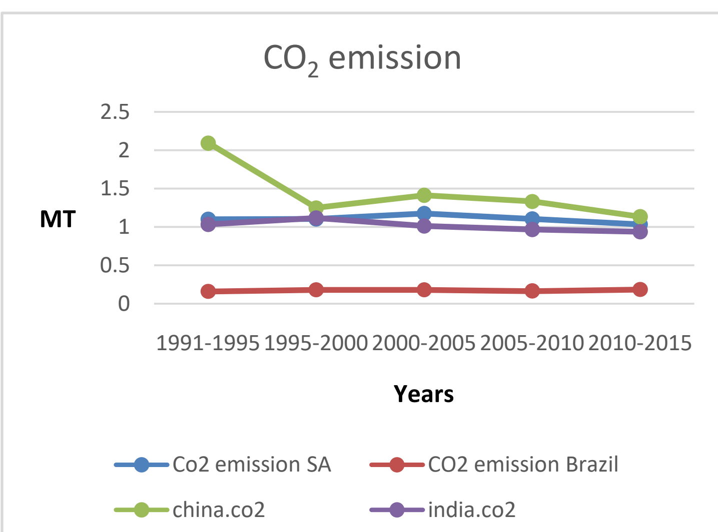
Hence: **Null H_0Rejected**

Results and Discussions: 1.4

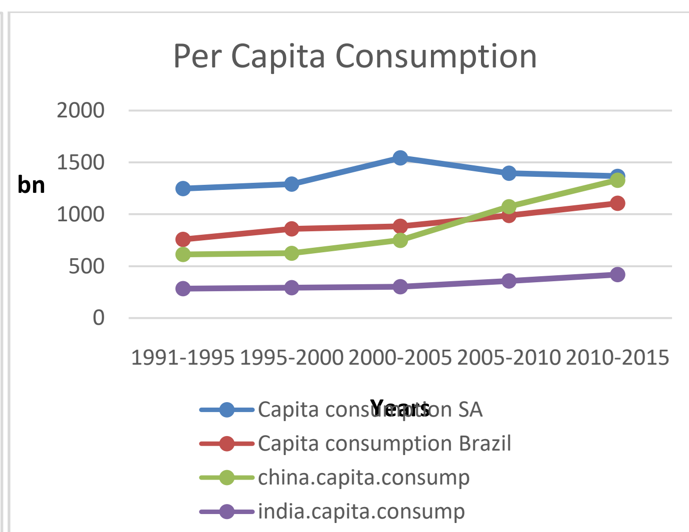
The below charts represents four countries energy dimension trends of past twenty five years starting from 1991 to 2015.

CO2 emission Rate, Per- Capita Energy Consumption's and Total Energy Demand

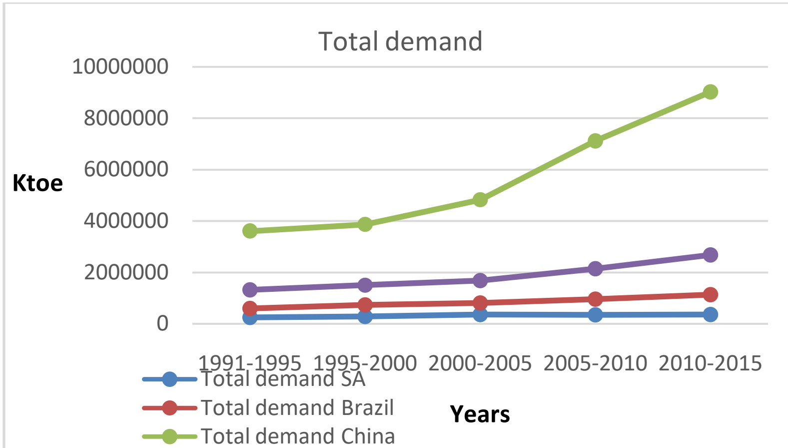
A



B



C



The above chart representsenergy performance of four countries and X axis denotes years and Y axis denotes quantities.

Chart **A** represent CO_2 emissions of fuel, which exhibits that CO_2 emission of China is at a higher point during 1991, and fell sharply thereafter till 1995; since 1995 to 2015 it is closer to India emission rate, but at a higher pace. On the other hand, India, which was at a moderate pace, recorded an increasing trend to the period of 1991-1995 and 1995-2000. After that it shows declining trend. South Africa's emission was slight lower than the emissions of India and China, whereas Brazil remained at lowest level.

Chart **B** shows per capita energy consumption of BICS. The highest amount per capita consumption is engendered by SA, starting from 1991 and shows highest increase during 2000-2005, and decline thereafter. The rate of per capita increase is more prominent for China, as compared to India, which lies at the lowest band, and Brazil increased its consumption rate more rapidly after 2005-2010, but China surpassed it after 2010.

Chart **C**showsthe total energy demand of BICS, which states that China grew at the rapid rate of growth in the total demand for period 1995-2000 to 2015,followed by SA which saw a boom in its energy demand after 2010. Therefore Brazil and India lie at a lower level of energy demand, as compared to China and SA.

Panel Data Regressions results: 1.5

Level of confidence 95%

Fixed-effects (within) regression Number of observations 100

Group variable: code Number of groups 4

CO2 emission	**Co.ef**	**P>|t|**	**T**
GDP	**- 0. 101**	**. 17**	-1.37
TPES	**0 . 003**	**0.00**	12.35
Cons	- *1.27*	**0.00**	-7.5
R2 within	*0.67*		

R2 between	*0.97*
R2 overall	*0.97*
α	*0.59*
µ	*0.33*
Rho	***0.75***

Allison says, "In a fixed effects model, the unobserved variables are allowed to have any associations whatsoever with the observed variables." Fixed effects models control for, or partial out, the effects of time-invariant variables with time-invariant effects".

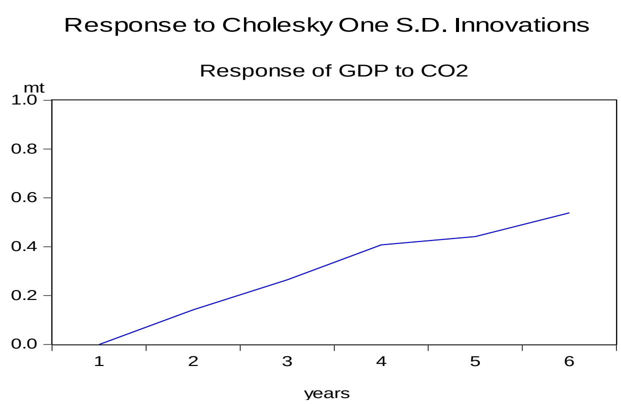
Panel data regression analysis is performed forthe cause and effect relationship between, within and overall variances in two independent variables by one dependent variable (**Yit**). Every year CO_2 emission, GDP and TPES value are divided by that year's population values to reduce the degree of freedom. Therefore,values represent per-capita GDP, TPES and CO_2 levels. The results of Hausman test suggest the analysis of the fixed effect model with P value less than 5 percent and null H_o: random effect is appropriate model.

The above table represents results of Panel Data Regression model the Hausman test enable us to opt for the fixed effect model. Therefore, starting with the R^2 between (individual mean minus overall mean) and R^2 overall (variable value minus overall mean) values suggest that there is immense increment in the quantity terms from 1991 to 2015. R^2 within (variable minus individual mean) suggest increment in the values were increasing gradually.The α represent the constant heterogeneity among the variables, µ the overall error value, and the rho value suggests that 0.75 percent variation, caused by endogenous variables, and rest are the idiosyncratic.

CO_2shows a negative relationship with GDP. Figure A shows that rate of GDP and CO_2 have increased over time, but at a decreasing rate, and single regression model shows that China and Brazil posses negative GDP with respect to emission,due to which impact on GDP is negative all over. Therefore, the rate of TPES suggests positive relation,which implies that as total primary supply of energy increased, the rate of CO_2 emission upsurged.

Impulse Response Function: 1.6

E



F

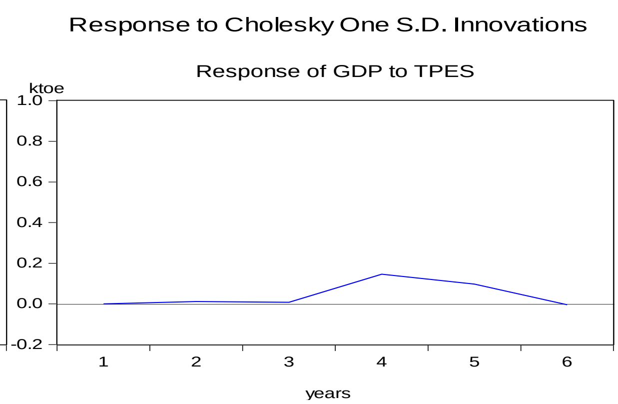
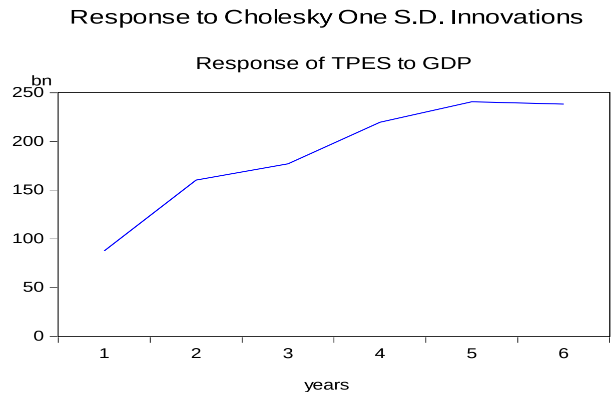


Chart E and F represent impulse response of GDP to $CO_2$and TPES. Chart E depicts six years' impulse rate of GDP to CO_2, which suggests that 1σ(S.D) positive shock will cause CO_2 to steeply increase for four years with agradual increase later. Therefore, in the case of chart F,GDP with 1σ shock, the TPES will remain constant till three years and then increase,with adecrease laterand become constant finally.

G



H

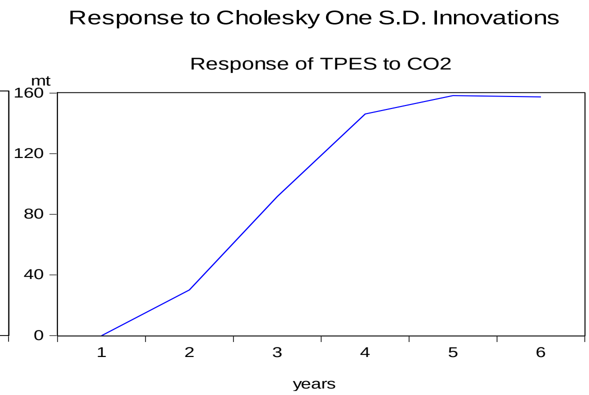


Chart G and H represent impulse response of TPES to $CO_2$and GDP. Chart G suggests 1σ positive shock in TPES will increase the GDP with inner bulge between second and third year, and then it will become constant after five years. Chart H with 1σ positive shock, the CO_2 level will increase rapidly after two years between second and fourth year, with a gradual increase till the fifth year, becoming constant thereafter.

Conclusions:

This paper concludesenergy trendsof BICS countries and calculatespercapita energy consumption, led by SA. Total energy consumption is led by China, as is the rate of CO_2 emissions.Panel regression model determines causality between GDP, TPES and CO_2 emissions. The results obtained suggest that GDP and CO_2 have a negative and non-linear relationship(Xinye Zheng • Yihua Yu • Jing Wang • 2014),(Xinye Zheng • Yihua Yu • Jing Wang •, 2017),(Jung Wan Lee & Tantatape Brahmasrene 2014)**,**whereas CO_2 has a positive relationship with TPES over time. Empirical evidence like(Wang 2013)also suggests that rate of GDP and CO_2 initially decline, then increase and then decline thereafter, which indicates towards the negative relation between GDP and CO_2 emission. China and South Africa exhibit a negative relationship between GDP and CO_2 emission.

The Johanson Co-Integration Test suggests that variables are highly co-integrated with each other, and TPES possessesthe closest relationship with the rate of emission, followed by GDP to TPES and GDP to CO_2 emission. China holds the first position in CO_2 emission, as also qualifiedby (Xinye Zheng • Yihua Yu • Jing Wang • 2014) and in total energy demand,whereas South Africa has the highest per-capita energy consumption. The Impulse Response Function shows future trends (2015-2021) of the three variables, which suggests that CO_2 will rise due to GDP and TPES in future,and a positive shock to the TPES will increase GDP, whereas a positive shock to the GDP will not cause TPES to riseuntilthree years.

The Increasing rate cause by GDP and TPES shows positive impact on Co_2but the empirical results shows that GDP and Co2 has negative relation, Co_2 increasing at decreasing rate in case of two countries this might be led through adoption of efficient techniques. Policy making itis important that we should adopt energy efficient techniques and developed nation should help developing nations while reducing the emission rate by transferring their technology knowledge. Lack of knowledge will increase emission rate and increase environmental cost.

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