The Tradeoffs between GHGs Emissions, Income Inequality and Productivity

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Abstract

Rising emission of greenhouse gasses (GHGs) and growing economic inequalities have emerged as key challenges for policymakers over the past two decades and the problems are likely to intensify in the foreseeable future. Numerous studies in the past have examined the relationship between these and implications on growth and equity of nations. Contributing to this literature, the present paper examines cross country differences in historical GHGs emission from 1990 to 2014 and analyzes the relationship between income inequality and emission levels and productivity. Additionally, we also inspect the role of energy use, equity and emission intensity. In doing so, data from the World Development Indicator is used for clusters of countries while also estimating sector specific trends in GHGs emissions for priority sectors such as agriculture and industry. The hypothesis is to validate whether economic growth improves the trade off with equity, and vice-versa. With the Paris Agreement (COP21) making veiled reference to the principle of common but differentiated responsibilities (CBDR) in tackling global warming the findings from the analysis would also signal towards efficacy of the targets set under the intended nationally determined contributions (INDCs).

Keywords: GHGs emission, income inequality, TFP

1. Introduction

The two foremost challenges for the twenty first century are reducing global poverty and mitigating climate change. The International Governmental Panel on Climate Change (IPCC) fifth assessment report (AR5) has restored the earlier versions that the warming of earth's climate system is unequivocal and since 1950s, many of the observed changes are

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unprecedented over the millennium (IPCC, 2014). Further, between the Kyoto Protocol (1998) and the Paris Climate Conference (2015)[3] it is observed that: (i) overall carbon inequalities measured in CO2e decreased (ii) a reduction in between-country emission and income inequalities and (iii) increase in within country emissions and income inequalities a part of which has been ascribed to the rise of China and other countries from the BRICS group (Piketty, 2015). Climate change is a global externality connected with the emission of six Kyoto greenhouse gasses due to human induced activities with respect to energy, industry, transport and land use (Stern, 2009). Also, there is considerable evidence from cross country comparisons that economic growth is generally associated with higher emission rates of carbon dioxide the main anthropogenic greenhouse gas at least till a certain level of economic development (IPCC, 2014; Jacob et al. 2014). Therefore with regards to developing economies although economic development is likely to alleviate poverty and inequality, nevertheless it could aggravate greenhouse gas emissions. In fact, Ravallion et al. (2000) suggest that a static tradeoff exists between climate control and both economic growth and social equity. Contributing to this literature the present paper additionally examines the role of productivity and improvements in innovation and R&D on emissions, equity and environmental degradation.

We re-examine these relationships using an updated dataset (1990-2014) from the World Development Indicators. In doing so we coalesce the theoretical model put forth by Ravallion et al. (2000) with models that attempt to measure productivity and performance in priority sectors like industries and agriculture. Econometric innovation with respect to the existing literature lies in using a cluster (group) fixed effects estimator (Bonhomme and Manresa, 2015) instead of a standard fixed effects estimator. This takes into account the differences in technologies, structures and dynamics among the BRICS[4] countries while also better dealing with endogeneity due to unobserved heterogeneity. Additionally, the standard pooled least

[3] The 2015 United Nations Climate Change Conference, COP 21 or CMP 11 was held in Paris, France, from 30 November to 12 December 2015. It was the 21st yearly session of the Conference of the Parties (COP) to the 1992 United Nations Framework Convention on Climate Change (UNFCCC) and the 11th session of the Meeting of the Parties to the 1997 Kyoto Protocol, "19th Session of the Conference of the Parties to the UNFCCC". International Institute for Sustainable Development

[4] BRIC is a grouping acronym that refers to the countries of Brazil, Russia, India and China, which are all deemed to be at a similar stage of newly advanced economic development. It is typically rendered as "the BRICs" or "the BRIC countries" or "the BRIC economies" or alternatively as the "Big Four". A related acronym, BRICS, includes South Africa. The acronym was coined in 2001 by Jim O'Neill from investment bank Goldman Sachs in a paper entitled "Building Better Global Economic BRICs". The acronym has come into widespread use as a symbol of the apparent shift in global economic power away from the developed G7 economies towards the developing world.

square estimators are also presented with the idea being to check the robustness of the group fixed effects estimates. Since the countries chosen for the study are based on a political definition, additional statistical tests are also undertaken to establish the case for using a group fixed effects model. The results are in line with the findings of earlier literature (for instance Ravallion et al. 2000) and additionally we find: (i) a significant negative relationship between productivity and greenhouse gas emissions, (ii) strong interacting effects between productivity and inequality, (iii) a positive relationship between emission intensity and value added in agriculture and industry and (iii) the group fixed effects presents interesting differentiated time trends linked closely to trends in emission in the individual country.

The remainder of this paper is organized as follows. Section 2 presents a discussion based on literature, section 3 presents data, methodology and the empirical strategy adopted for analyzing the objectives of the paper. Section 4 presents the results and discussion. Finally, section 5 presents the summary and conclusions.

2. Review of literature

Developing and developed countries are in a serious conflict over the issue of carbon reduction, a conflict that arises from the determination of emission targets based on historical cumulative emissions or per capita emissions. This problem, in turn, is the result of two critical gaps - the gap in development stages and the gap in income levels - between developing and developed countries. The two gaps can be theoretically explained by the income Kuznets curve and the environmental Kuznets curve. Panayotou (1993) first coined the term “Environmental Kuznets Curve” (EKC) because of its resemblance to the Kuznets hypothesis (Kuznets, 1955). Since then, Selden and Song (1994), Grossman and Krueger (1995) and others have found evidence supporting the new hypothesis that the level of environmental degradation and income per capita follow an inverted-U-shaped pattern. The EKC has since become a key concept in describing the relationship between environmental quality and per capita income. There are also studies that focus on the “Carbon Kuznets Curve” (CKC). Xu and Song (2011) found that carbon emissions per capita of the eastern region and the central region of China fit into the environmental Kuznets Curve, while that of the western region does not, based on provincial panel data for China over the period of 1990 to 2007.

In the literature, some studies find that the increase in CO_2 emissions dues to economic growth depends not only on income level, but also on the distribution of growth (Brannlund and Ghalwash, 2008). Therefore, the distributional inequality of income should be an explanatory variable in the EKC relationship, along with the mean income level (Coondoo and Dinda, 2008). There are also studies that support the positive effect of income inequality on pollution. Boyce (1994), for example, adheres to the public good choice theory, arguing that greater inequalities of power and wealth lead to increased environmental degradation. Torras and Boyce (1998) support their hypothesis that a more equitable distribution of power contributes to the air and water quality based on an empirical analysis of international variations in seven indicators of air and water quality. Magnani (2000) finds that moments of the income distribution function rather than the mean income may be important for the emergence of an appropriate path of sustainable growth in high income countries. However, other studies provide evidence for a negative effect of income inequality. Ravallion et al. (1997) identify the trade-off between climate control and social equity, and Scruggs (1998) shows that under some plausible conditions, greater inequality may even be conducive to lower degradation. Additionally, Ravallion et al. (2000) find that higher inequality both between and within countries is associated with lower carbon emissions at given average incomes, and Heerink et al. (2001) demonstrate the importance of income distribution as an explanatory variable in the “income-pollution” relationship at the household level.

There are also studies that focus on the effect of income inequality on pollution in individual countries. For example, Nugent and Sarma (2002) use an environmentally extended computable general equilibrium model (EECGE) for India to demonstrate that simple policy changes can be enacted to simultaneously increase distributional equity, environmental sustainability, and growth-increasing efficiency. Yang et al. (2011) conclude that there is a significantly negative relationship between environmental quality and income inequality in China at the present time. Clarke-Sather et al. (2011) find that at a national scale, interprovincial levels of inequality in per capita CO_2 emissions are similar to, but slightly lower than, inequality levels in per capita GDP in China. With respect to the effect of income distribution on CO_2 emission distribution, studies show that income inequality may affect the distribution of CO_2 emissions. Duro and Padilla (2006) suggest that international inequality in per capita CO_2 emissions is mainly attributable to inequalities in per capita income levels, which explains, in part, the recent carbon emission reduction issue. Padilla and Serrano (2006) conclude that inequality in CO_2 emissions is mostly explained by the inequality between groups with different per capita income levels. Coondoo and Dinda (2008) confirm that inter-country income inequality has a significant effect on the mean emission levels and inter-country inequality of emissions for most of the country groups considered. Jha and Murthy (2003) emphasized the role played by the level of global environmental degradation (GED) in economic development and developed a composite environmental degradation index (EDI) using Principal Components Analysis (PCA) and relate it to an appropriate measure of economic development, i.e., the human development index (HDI), with a view toward developing a global EKC (GEKC) for 174 countries.

Because the issue of climate change has been attracting worldwide attention, studies of the driving forces behind CO2 emissions have been of considerable interest to researchers and policy makers. Most studies estimate the turning point of the emissions of pollutant using the reduced form of environmental Kuznets curve (EKC), taking the mean per capita income as the main explanatory variable. However, Selden and Song (1994) and Stern et al. (1996) note that using the mean per capita income leads to a misinterpretation of the turning point. They point out that because income is not normally distributed but very skewed with much larger numbers of people below mean per capita income than above it, the estimated turning point using the mean per capita income is lower than the actual turning point. To reduce the chance of this misinterpretation, some studies begin to focus on the impact of income distribution pattern in the EKC relationship. However, only a few studies have been conducted to examine the impact of income disparity on carbon emissions. Therefore, it remains difficult to fully understand the effect of income distribution on the mean carbon emissions levels. Most studies on EKC have typically expressed environmental quality as a function of average income and ignored the distribution of the income as a potential factor. An approach to improving research in this field is to introduce distribution into the income-pollution relationship. Studies that consider the distribution of income have obtained conflicting conclusions. A number of studies support the positive effect of income inequality on pollution. Boyce (1994) uses the public good choice theory to argue that a society's choice of the environmental quality level can be determined by the distribution patterns of income and societal power. Greater inequalities of power and wealth lead to a greater level of environmental degradation. Torras and Boyce (1998) support their hypothesis that a more equitable distribution of power contributes to improved air and water quality using an empirical analysis of international variations with seven indicators of air and water quality.

3. Data and methodology

This section of the study presents the data and methodology used for the empirical analysis. Data is secondary in nature, collected from the World Development Indicators (WDI) for the BRICS countries from 1991-2014. WDI reports numerous information however for the purpose of this study we have selected the following data. GHGs emissions, GDP per capita, Gini index, population, net energy use, value added, capital, labour, energy consumption, industrial value added, and agriculture value added. One of the reasons for the selection of the time trend is related to opening up the Indian economy and the second is the consistency in data during the time for the five countries on all the variables. The unit of measurements for each of the variables are presented in table A-1 in the annex. Once, the variables of interests are selected, the next step is to calculate country specific productivity. Given the availability of variables, we don't have information on the materials consumed hence traditional production functions cannot be used. The most appropriate functional form is suggested to be the Levinsohn and Petrin (2003). Productivity growth is essential not only to increase output, but also to improve the competitiveness of an economy. The growth of an economy is driven by two distinct sources namely input choices and productivity. The input-driven growth is achieved through increase in factors of production that is subjected to diminishing returns and may not be sustainable in the long run. In the productivity literature, total factor productivity (TFP) is considered to be one of the plausible routes to measure the welfare of the economy. Here, an attempt is made to relate total factor productivity with the emission to check whether non neutral technological change helps in reducing emission from the stated countries. For the theoretical understanding of this paper we use Ravallion et al. (2000). We improvise the empirical analysis of Ravallion et al. (2000) including variables related to technology such as the total factor productivity and nonlinear relation of productivity. Also, we have experimented with the interaction variables with the time trend and Gini index of inequality.

Considering the theoretical arguments presented in Ravallion et al. (2000) the functional form of the econometric model to capture the GHGs emissions, income inequality and technology in country *j* in time *t* takes the following functional form.

$$\ln E_{ji} = \beta_{1j} \ln \bar{Y}_{ji} + \beta_{2j} \left(\ln \bar{Y}_{ji} \right)^2 + \beta_{3j} \ln N_{ji} + \beta_{4j} t + \eta_j + \varepsilon_{ji} \qquad (1)$$

Where, β parameters are assumed to be linear functions of measured income inequality. Equation (1) includes country fixed effect which we take to be a linear function of inequality. The income elasticity and effects of inequality and technology on emission can be computed by estimating equation (1). For the empirical purpose, we have estimated the base equation in restricted and unrestricted forms. The unrestricted form of the estimated equation is as follows:

$$\begin{aligned} \text{LGHG}_{\text{E}_{jt}} = {} & \alpha_{it} + \beta_1 LPGDP_{jt} + \beta_2 LPGDP^2{}_{jt} + \beta_3 LPOP_{jt} + \beta_4 t + \beta_5 LE_{USE_{jt}} + \\ & \beta_6 GINI_{jt} + \beta_7 (LPOP * GINI)_{jt} + \beta_8 (LPGDP * GINI)_{jt} + \varepsilon_{jt} \end{aligned} \quad (2)$$

In estimating equation two, one of the experiments that carried out is related to drop ln of population in one of the estimation to find out the impact of population on the estimates. Similarly, the first form of the restricted form of the empirical equation takes the following functional form:

$$\begin{aligned} \text{LGHG}_{\text{E}_{jt}} = {} & \alpha_{it} + \beta_1 LPOP_{jt} + \beta_2 t_{jt} + \beta_3 LE_{USE_{jt}} + \beta_4 GINI_{jt} + \beta_5 (LPGDP * GINI)_{jt} + \\ & \beta_6 (t * GINI)_{jt} + \beta_7 (LE_{USE} * GINI)_{jt} + \beta_8 TFP_{jt} + \beta_9 TFP^2_{jt} + \varepsilon_{jt} \end{aligned} \quad (3)$$

In a modification to the restricted model we use the following testable model:

$$\begin{aligned} \text{LGHG}_{\text{E}_{jt}} = {} & \alpha_{it} + \beta_1 LPOP_{jt} + \beta_2 LE_{USE_{jt}} + \beta_3 GINI_{jt} + \beta_4 (t * GINI)_{jt} + \\ & \beta_5 (LE_{USE} * GINI)_{jt} + + \beta_6 TFP_{jt} + \beta_7 TFP^2_{jt} + \varepsilon_{jt} \end{aligned} \quad (4)$$

Further, we attempt to understand the determinants of GHGs emission intensity using the similar framework using the following functional form. This enables us to relate the impact of sub-sectors of economies such as the agriculture and the industrial sectors.

$$\begin{aligned} \text{IGHG}_{\text{E}_{jt}} = {} & \alpha_{it} + \beta_1 LNGDP_{jt} + \beta_2 LNGDP^2_{jt} + \beta_3 LPOP_{jt} + \beta_4 LE_{USE_{jt}} + \beta_5 GINI_{jt} + \\ & \beta_6 (T * GINI)_{jt} + \beta_7 (LE_{USE} * GINI)_{jt} + \beta_8 LI_{VA\,jt} + \beta_9 LAG_{VA\,jt} + \varepsilon_{jt} \end{aligned} \quad (5)$$

As stated we have used a panel data for the empirical analysis. Therefore, before estimating the above equations, we have conducted the diagnostic tests a prior to the estimations such as the BLUE assumptions and cross-section/time series dependency of the panel data. The results of these exercises are presented in the appendix tables. Once the factors explaining inter-country differences in GHGs emissions and GHGs emission intensity are arrived at in general and related to the inequality and technology in particular, the next approach of this paper is to decompose and arrive at the differentials based on the Gini index for the countries in context. Here we use Blinder-Oaxaca Decomposition.

An often used methodology to study economic outcomes by groups is to decompose mean differences based on linear regression models in a counterfactual manner. The procedure is known in the literature as the Blinder-Oaxaca decomposition. It divides the differential between two groups into a part that is “explained” by group differences in productivity characteristics, and a residual part that cannot be accounted for by such differences in wage determinants. This “unexplained” part is often used as a measure for discrimination, but it also subsumes the effects of group differences in unobserved predictors. This technique can be employed to study group differences in any (continuous and unbounded) outcome variable. In the case of this paper, we have identified two groups based on inequality within the countries, meaning a group of observations less than that of the mean Gini index and the other group higher than that of the mean Gini index. Based on the decomposition we attempt to differentiate two identifiable groups the first for Gini index less than mean for each country, and the second for Gini index more than mean for each country. The results of the empirical estimations are presented in the next section.

4. Results and discussion

The first part of the analysis examines the relationship between the total GHG emissions and a host of indicators depicting the per capita income, level of inequality and a few interaction effects. A country fixed effects was used for the estimation and the results are presented in columns 1 and 2 of table 3. This method recognizes that unobserved fixed effects could be correlated with the regressors in the model and therefore the use of pooled least squares model would introduce a source for bias. Hence if the measurement errors are ignored, it can be assumed that the income and population elasticities could be better estimated by the fixed affects model as it purges the estimates of any correlated fixed effects (Ravallion et.al. 2000). The results confirm the presence an EKC relationship as also stated by many previous studies. There is evidence of total emissions rising with increases in per capita income of the countries however only till a certain point. The coefficient for the quadratic term of per capita income is statistically significant with a negative sign indicating the decrease in marginal propensity of emissions up to relatively higher incomes. Although no other variable turns up significant in the formulation yet the joint restriction that all estimated coefficients are zero is strongly rejected.

The second specification used in the estimations throws some interesting results. Here the variables depicting population size in not included in the model and likewise the variable capturing the interaction effects of population and the measure of inequality. As before, we find even stronger evidence of existence of an EKC relationship. The variable depicting the time trend is significant and positive. Hence over the period of analysis the overall emissions across the countries have been increasing in the range 10-12 percent. However the growth of emissions has been lower than the growth of per capita income. On the other hand the results suggest that the Gini coefficient is positive and significant implying that inequalities within countries have increased over the period of analysis. The result obtained for the interaction variable involving per capita income and Gini suggests that the actual rate increase in per capita income and income inequality is a little lesser than that was envisaged through specification 1 in table 3.

The results presented in column 3 of table 2 describe the results from the estimation of equation. Among other variables considered a new variable was added into the model that quantifies the energy use in a country (imports – exports). The impact of population on the total emissions is highly significant in this case indicating higher emissions for more populated countries. So also is the case with higher energy use. The subsequent model attempts to capture the impact technological improvement on the total emissions. Technological improvements included in the model are the estimated total factor productivity coefficients obtained through the Levinson-Petrin method. The results point to some interesting observations. The variable per se appears with a positive sign suggesting that increases in productivity also result in higher emissions till a particular level. Since the quadratic form of total factor productivity is negative there is evidence that beyond a point emissions tend to decrease, a relationship that is also exhibited by per capita income. Further this model suggests that accounting for total factor productivity the income inequalities are decreasing over years across the sets of countries. The final column in table 2 reports the results if the change the outcome variable from total emissions to intensity of total emissions and include two new explanatory variables that capture the value added in industry and agriculture sectors. The results for per capita income and squared per capita income are expected as the dependent variable is now a variable capturing intensity. The emissions as a share of per cpaita income decrease with marginal increases in population and emissions per unit of output decrease with higher levels of inequality. It is also observed that higher energy use also enhances the emissions per output. It also appears that the contribution of industrial output to per unit emissions is much higher than that of agricultural sector. In fact the contribution from the industrial sector is more than double of the agricultural sector. Similarly it is also observed that accounting for energy usage the higher per unit emissions also could result in inequalities being lower within countries. Having established the behavior of different explanatory variables on total emissions and emissions per unit of output then next objective is to examine the mean outcome differences between different countries. In particular the objective is to know the differences between the emission levels across these countries through a set of explanatory variables. As described earlier the methodology to do so involves the usage of Blinder-Oxaca decomposition for linear regression models. The results obtained from this exercise are presented in table 4.

The countries in the analysis are divided into two groups: (i) group one that represents the countries with Gini index less than mean for each country and (ii) group two that consists of countries with the Gini index more than mean for each country. The results show that the total emissions are higher for countries with higher inequalities than the average Gini for all the five countries taken together. The total emissions for countries with lower inequality is around 13.17 while for the country with above average value of Gini index is around 14.32 thus yielding a gap in emissions between the two groups is around 1.15. The total emission of countries with a lower Gini index is lesser by approximately 15 percent lower than those with inequality level higher than the average value. The explanatory variables used in the model (population, energy use and total factor productivity) explain for approximately 81 percent of the observed differences in total emissions.

5. Conclusion

Rising emission of greenhouse gasses (GHGs), growing economic inequalities and environmental degradation have emerged as key challenges for policymakers over the past two decades and the problems are likely to intensify in the foreseeable future. Numerous studies in the past have examined the relationship between these and implications on growth and equity of nations. The International Governmental Panel on Climate Change (IPCC) fifth assessment report has restored the earlier versions that the warming of earth’s climate system is unequivocal and since 1950s, many of the observed changes are unprecedented over the millennium. Further, between the Kyoto Protocol (1998) and the Paris Climate Conference (2015) it is observed that; overall carbon inequalities measured in CO2e decreased, a reduction in between-country emission and income inequalities and increase in within country emissions and income inequalities a part of which has been ascribed to the rise of China and other countries from the BRICS group. Ravallion et al. (2000) suggest that a static tradeoff exists between climate control and both economic growth and social equity. Contributing to this literature the present paper additionally examines the role of productivity and improvements in innovation and R&D on emissions, equity and environmental degradation. We re-examine these relationships using an updated dataset (1990-2014) from the World Development Indicators. In doing so we coalesce the theoretical model put forth by Ravallion et al. (2000) with models that attempt to measure productivity and performance in priority sectors like industries and agriculture. The results are in line with the findings of earlier literature and additionally we find: (i) a significant negative relationship between productivity and greenhouse gas emissions, (ii) strong interacting effects between productivity and inequality, (iii) a positive relationship between emission intensity and value added in agriculture and industry and (iii) the group fixed effects presents interesting differentiated time trends linked closely to trends in emission in the individual country. From the decomposition analysis we confirm that total emissions are higher for countries with higher inequalities than the average Gini for all the five countries taken together. The total emissions for countries with lower inequality is around 13.17 while for the country with above average value of Gini index is around 14.32 thus yielding a gap in emissions between the two groups is around 1.15. The total emission of countries with a lower Gini index is lesser by approximately 15 percent lower than those with inequality level higher than the average value.

Table-1: Mean and Standard deviation of variables

Country	GHG_E ('0000)	CO_2	POP ('0000)	PGDP	GINI	E_{USE} (%)	TFP	I_{VA} ('000000)	AG_{VA}
Brazil	43.80	30.14	18000.00	4723.70	56.45	92.72	27.50	217000.00	237645.70
	(27.73)	(2.41)	(1750.00)	(649.77)	(3.95)	(1.81)	(0.20)	(46500.00)	(62195.03)
China	495.96	35.59	127000.00	1679.02	43.31	273.86	29.64	1030000.00	365687.20
	(268.89)	(3.73)	(6880.00)	(1053.86)	(8.46)	(86.46)	(0.42)	(752000.00)	(214122.70)
India	151.72	25.10	109000.00	697.57	43.67	164.36	29.74	202000.00	211126.50
	(60.54)	(5.03)	(13200.00)	(261.11)	(3.93)	(28.72)	(0.36)	(99600.00)	(121579.80)
Russian Federation	164.59	14.94	14600.00	5052.60	41.45	287.90	27.76	232000.00	129043.30
	(55.25)	(5.95)	(237.61)	(1278.65)	(2.76)	(55.59)	(0.23)	(54900.00)	(82605.89)
South Africa	81.30	20.34	4480.00	5285.31	51.84	246.33	26.11	65500.00	109518.50
	(211.31)	(5.39)	(575.29)	(539.50)	(7.26)	(16.87)	(0.26)	(8180.00)	(110344.60)
Total	187.47	25.22	54500.00	3487.64	47.34	213.03	28.15	350000.00	210604.20
	(223.76)	(8.59)	(52800.00)	(2089.24)	(8.08)	(88.07)	(1.41)	(483000.00)	(156712.00)

Standard deviations are presented in the brackets

Table-2: GHGs emission regressed on cubic function of average income

	(1)	(2)
Variables	Pooled OLS	Fixed Effects
PGDP	5,152***	5,519***
	(1,035)	(1,567)
$PGDP^2$	-1.321***	-1.397***
	(0.432)	(0.476)
$PGDP^3$	0.000109**	0.0001**
	(0.00004)	(0.00004)
POP	0.00478***	-0.00677*
	(0.00144)	(0.00371)
T	38,807	-60,757*
	(27,529)	(32,930)
Constant	-6749271***	1212000
	(1323526)	(2201000)
N	125	125
R^2	0.555	0.246
Number of groups	-	5
Country FE	No	Yes

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1, Data source: WDI indicators

Table-4: Results of Fixed Effects

Variables	Unrestricted		Restricted		
	(1)	(2)	(3)	(4)	(5)
LPGDP	4.977**	5.972***	-	-	-3.736***
	(1.997)	(1.645)			(0.662)
$LPGDP^2$	-0.326**	-0.396***	-	-	0.199***
	(0.137)	(0.112)			(0.043)
LPOP	1.049	-	2.859***	3.397***	-0.007***
	(1.119)		(0.915)	(0.499)	(0.002)
t	0.094	0.125**	0.088	-	-
	(0.058)	(0.057)	(0.058)		
LE_{USE}	-	0.277	0.951*	0.408*	0.845***
		(0.739)	(0.516)	(0.184)	(0.058)
GINI	0.029	0.053***	0.022	-7.535**	0.158***
	(0.080)	(0.020)	(0.022)	(2.028)	(0.037)
LPOP*GINI	0.001	-	-	-	-
	(0.009)				
LPGDP*GINI	-0.002	-0.003***	-0.001	-	-
	(0.001)	(0.001)	(0.001)		
t*GINI	-	-	-	-29.84**	-13.46***
				(7.323)	(0.962)
LE_{USE}* GINI	-	-	-	0.526**	0.238***
				(0.131)	(0.016)
TFP	-	-	-	0.546**	-
				(0.148)	
TFP^2	-	-	-	-0.010**	-
				(0.00270)	
LI_{VA}	-	-	-	-	0.652***
					(0.151)
LAG_{VA}	-	-	-	-	0.308**
					(0.137)
Constant	-26.95	-9.18	-38.00**	372.0**	185.7***
	(18.44)	(8.40)	(17.50)	(95.92)	(13.36)
N	125	125	125	125	125
R^2	0.209	0.203	0.181	0.184	0.172
No of groups	5	5	5	5	5
Country FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Hausman (p value)	0.002***	0.000***	0.004***	0.004***	0.000***
Outcome Variable	$LGHG_E$	$LGHG_E$	$LGHG_E$	$LGHG_E$	$IGHG_E$

Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table-5: Blinder-Oaxaca Decomposition

Number of observations = 125, Identifiable groups (1) =0 for Gini index less than mean for each country (2) =1 for Gini index more than mean for each country

$LGHG_E$	Coef.	Std. Err.	Z	Coef.	Std. Err.	Z
			Differential			
Prediction_1	13.167	0.132	99.830***	13.167	0.129	101.700***
Prediction_2	14.316	0.103	139.030***	14.316	0.102	140.200***
Difference	-1.149	0.167	-6.870***	-1.149	0.165	-6.970***
			Decomposition			
Endowments	-1.766	0.250	-7.070***	-	-	-
Coefficients	0.415	0.310	1.340	-	-	-
Explained	-	-	-	-1.426	0.159	-8.980***
Unexplained	-	-	-	0.277	0.132	2.100**
Interaction	0.202	0.352	0.570	-	-	-
			Endowments			
LNPOP	0.785	0.325	2.410***	-	-	-
LE_{USE}	-0.688	0.180	-3.830***	-	-	-
TFP	-1.863	0.447	-4.170***	-	-	-

Appendix table-1: Variables and unit of measurement

Sl. No.	Variable	Unit of measurement
1	GHGs emission	Mt of CO2 equivalent
2	GDP per capita	Constant 2005 US$
3	Gini	World Bank estimates
4	Population	Number
5	Value added	Gross value added at factor cost (constant 2005 US$)
6	Energy consumption	kg of oil equivalent
7	Capital	Constant 2005 US$
8	Labour	Number
9	Industrial value added	Constant 2005 US$
10	Agriculture value added	Constant 2005 US$

Appendix table-2: Diagnostics Tests Results (OLS)

Test	M1	M2	M3	M4	M5	M6
Multicolinearity	6.32	4.24	2.31	1.78	4.47	1.41
Skewness	8.67	9.47	2.67	6.47	4.32	5.62
Kurtosis	1.58	1.53	13.50	1.53	1.15	1.44
Heteroskedasticity	8.95	5.32	2.09	3.16	3.65	2.80
Ramsey test	2.83	3.35	3.18	2.89	4.35	3.17

Appendix table-3: Diagnostics Tests Results (Panel with time trend)

Variables	Panel Unit Root Levin-Lin-Chu	Panel Unit Root Hadri
$LGHG_E$	4.553***	2.884***
LPGDP	-2.810***	17.540***
LPGDP*Gini	-0.904	2.026**
LPOP	-1.536	25.495***
LE_{USE}	-0.338	15.836***
GINI	-0.924	1.669*
TFP	-3.276***	17.728***
LI_{VA}	-4.438***	14.890***
LAG_{VA}	-1.064	8.448***

Appendix table-4: Test for cross-sectional dependence

Test	M7	M8	M9	M10	M11	M12
Pesaran (2004) [Standard normal distribution]	4.211***	4.050***	3.745***	4.206***	3.427***	3.162***
Frees test [Frees' Q distribution (T-asymptotically distributed)]	0.796***	0.689***	0.590***	0.929***	0.501***	0.885***

Critical values of free's Q distribution are; 0.103, 0.135 and 0.194 at 10%, 5% and 1% respectively

Figure-1: GHGs emissions and Population

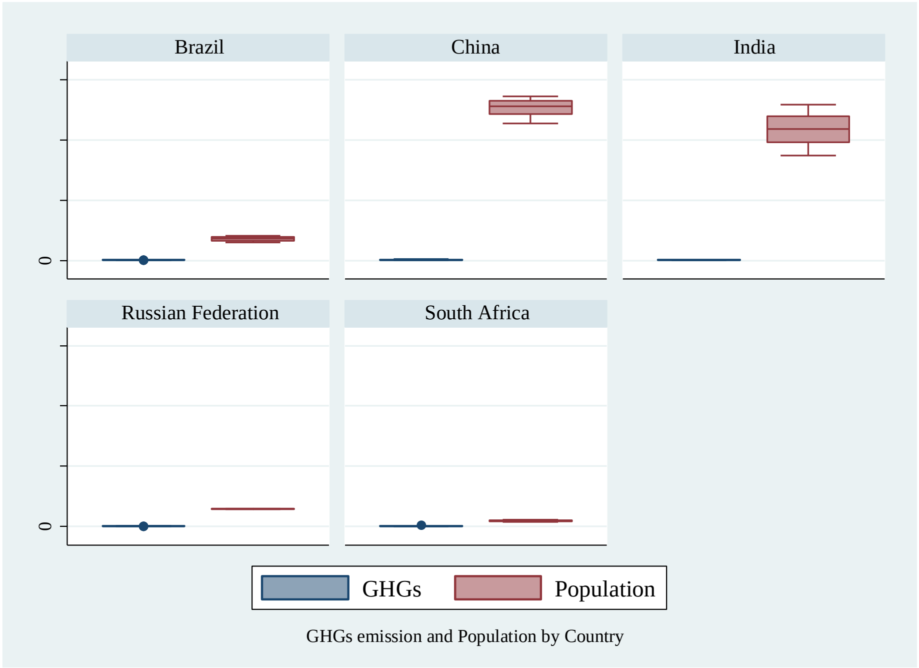
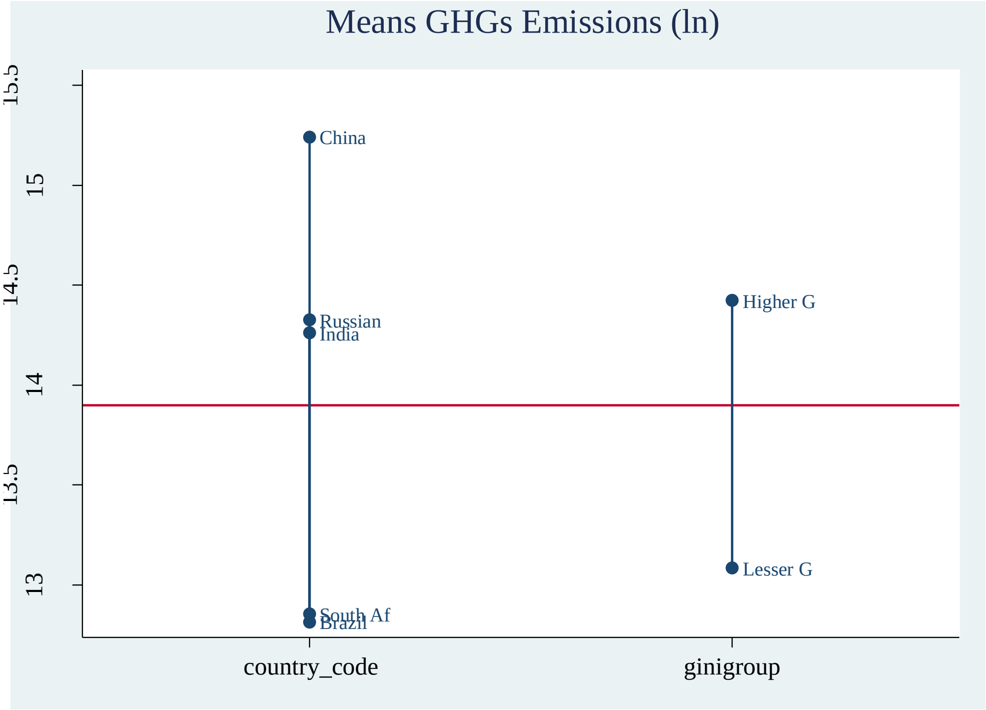


Figure 2: Mean GHGs emissions



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