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Wealth inequality and CO_2 emissions in emerging economies

The case of BRICS

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Abstract: As the world battles with the triple problems of social, economic, and environmental challenges, it has become important to focus both policy and research efforts on these. Therefore, this study examines the effect of wealth inequality on CO_2 emissions in five emerging economies: Brazil, Russia, India, China, and South Africa. The top decile of wealth share was used as a measure of wealth inequality, while CO_2 emissions per capita were used as a measure of CO_2 emissions. GDP per capita, population, and financial development (domestic credit to the private sector) were included as control variables. A balanced panel dataset of annual observations from 2000 to 2014 for these countries was used. Both fixed and random effects panel models were estimated, but the Hausman test favoured the use of the fixed effects model. The results based on the fixed effects panel regression model show that wealth inequality, GDP per capita, and population have positive effects on CO_2 emissions, while financial development has a negative effect.

Key words: CO_2 emissions, emerging economies, fixed effects, random effects, wealth inequality

JEL classification: C23, D31, Q52, Q54

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1 Introduction

Globally, inequality and climate change have become a prominent issue in the policy and research arena. For example, both inequality and environmental degradation featured clearly in the sustainable development goals (SDGs). The SDGs emphasized having a 'plan of action for people, planet and prosperity'. Goal 10 in the SDGs is aimed at reducing inequality within and among countries such that by 2030 the income growth of the bottom 40 per cent of the population is at a higher rate than the national average. The increasing interest in inequality is due to the rising trend observed over time. Several countries in the world are unequal in terms of both income and wealth. The BRICS countries (Brazil, Russia, India, China, and South Africa), which are the focus of this study, are no exception. For example, South Africa is among the countries with the highest income inequality, its income Gini coefficient being 0.63 in 2015 (World Bank 2018). Moreover, South Africa's wealth Gini was 0.84 in the same year, though it has been shown to have declined to 0.81 by 2018 (Shorrocks 2015, 2018).

The level and trend of income and wealth equality should be of paramount concern to policy-makers since inequality has consequences on the economy and can lead to social discontent. Moreover, it has recently been argued that inequality is partly responsible for increasing greenhouse gas emissions and consequently for global warming, irrespective of the country in which it is found. The British Charity Oxfam reported that the richest 10 per cent in the world contribute about 50 per cent of global carbon emissions, while the poorest 50 per cent contribute only 10 per cent (Oxfam International 2015).

Theoretical channels through which inequality could affect CO_2 emissions are highlighted in Jorgenson et al. (2017) and Knight et al. (2017). These include labour and consumption dynamics, which are driven largely by income inequality. For instance, According to Ravallion et al. (2000), when the relationship between household income and emissions is concave, the poor emit more than the wealthy for each dollar of additional income, so that income redistribution from the wealthy to the poor will result in increased emissions. They further hypothesized that the marginal propensity to emit is due to rise in disposable income, which leads to increasing consumption. In other words, when the poor graduate into the middle class as a result of income redistribution, their propensity to consume more carbon-intensive products such as energy will increase (Jorgenson et al. 2017; Zhang and Zhao 2014).

Another channel is related to the Veblen (1934) effect. This posits that the wealthy aim to gain status or popularity by consuming expensive goods and services that are very visible to the public. This implies that competition for consumption could result from heightened inequality (Schor 1998), which will consequently increase emissions. In other words, inequality could induce status competition as high-income households spend more to maintain their visible lifestyles. This channel is also related to the finding that working hours increase as a result of inequality (Bowles and Park 2005), since increased working hours mean increasing consumption of energy and CO_2 emissions (Fitzgerald et al. 2015; Knight et al. 2013).

However, of particular importance to this study is the political economy approach of Boyce (1994), which was developed further by Boyce (2007) and Downey (2015). It is assumed that the concentration of wealth affects environmental policy through political influence. According to Boyce, wealthy individuals benefit disproportionately from polluting activities by being owners of companies that are engaged in such activities and by being better able to protect themselves against the negative impacts of pollution. Moreover, the political economy framework centres on the 'power-weighted social decision rule', which states that

> when the beneficiaries of environmental degradation are more powerful than those who bear the costs, the overall level of environmental degradation will be greater. The affluent benefit more from environmental degradation (as both producers and consumers), while the poor benefit less and are more vulnerable to the harmful consequences (e.g., pollution, proximity to industrial activities). Therefore, greater economic inequality is likely to lead to increased environmental degradation as the interests of the affluent are protected in the political realm (Cushing et al. 2015).

Some empirical studies have examined the effect of inequality on CO_2 emissions (Jorgenson et al. 2015; Jorgenson et al. 2016; Jorgenson et al. 2017; Knight et al. 2017; Ravallion et al. 2000). But only Knight et al. (2017) focused on wealth inequality, while all the other studies used income inequality as a measure of economic inequality—and an analysis of 17 OECD countries has shown that the relationship between income and wealth inequality is weak (OECD 2015). Indeed, it is argued that wealth is more unequally distributed than income (Kus 2016). Hence, one may be making wrong assumptions by assuming that income and wealth inequality will have similar effects on CO_2 emissions.

The only closely related study, Knight et al. (2017), focused on high-income countries and by construction eliminated upper-middle- and/or low-income countries. The objective of this paper is to examine the role of wealth inequality on anthropogenic CO_2 emissions in the BRICS countries. These countries belong mainly to the upper-middle-income group, with the exception of India, which is in the lower-middle-income group. The findings from analysing the data from these countries will shed light on the case of emerging economies as the magnitude and/or direction of the effect of wealth inequality on CO_2 emissions may differ between different groups of countries.

The rest of the paper is organized as follows: the review of literature is presented in Section 2; the methodology is discussed in Section 3; results are presented and discussed in Section 4; and Section 5 concludes.

2 Literature review

The relationship between CO_2 emissions and inequality has received little attention in the literature, the relation between wealth inequality and income inequality even less. This section reviews the previous empirical studies on these relationships. The results are mixed, as some found a negative relationship and some a positive relationship, while others found non-significant effects.

Ravallion et al. (2000) analysed the effect of carbon emissions on income inequality for 42 countries using panel data from 1975 to 1992. Results based on pooled and fixed effects panel models showed that inequality has a negative relationship with carbon emissions. That is, rising inequality lowers carbon emissions while economic growth increases emissions. However, the authors demonstrated that better long-term trajectories of carbon emissions could be achieved by combining growth and equity objectives.

Coondoo and Dinda (2008) investigated the relationship between, CO_2 emissions, temporal shifts, and inter-country income inequality for four groups of countries, namely those in Africa, Europe, Asia, and America. The study also examined the distributional impact of the per-capita mean of CO_2 emissions. They found statistically significant cointegrating vectors between the income inequality and emissions variables. Results from regression-based models, specifically fixed and random effects as well as a nonlinear regression, show that inter-country income inequality has a significant effect on emissions for most of the studied country groups, although the quality varies. For instance, while equal income redistribution would increase the level of emissions in Europe and America, the effects in Asia and Africa, which are poorer, would not be significant.

Grunewald et al. (2011) examined the relationship between emissions and income inequality for 138 countries from 1960 to 2008. They found that the relationship is U-shaped, as rising income inequality reduces emissions in countries that are more equal but increases emissions in more unequal countries. Poor countries usually have a higher inflection point than wealthy countries, suggesting that wealthy countries with high income inequality may experience lower emissions with redistribution, but that this may not be the case for poorer countries.

Zhang and Zhao (2014) investigated the impact of income inequality on CO_2 emissions using regional and national level data in China from 1995 to 2010. The control variables included are GDP per capita, share of industry sector, and urbanization. Results based on several panel estimations show that inequality has a positive relationship with carbon emissions. In other words, CO_2 emissions in China tend to reduce with declining income inequality. Therefore, ceteris paribus, an equalizing redistribution of income would decrease CO_2 emissions.

Jorgenson et al. (2015) analysed the relationship between income inequality and US state-level residential carbon emissions from 1990 to 2012. The study used several panel approaches, which can be summarized as fixed and random effects models. The control variables included were population size and GDP per capita, as well as census regions in the random effects model. They found that the Theil Index, their measure of inequality, has a positive effect on residential carbon emissions.

Jorgenson et al. (2016) examined the relationship between carbon emissions and income inequality in 67 countries using data from 1991 to 2008 and a two-way fixed effects longitudinal model. Their results show that the relationship varies with time and across countries. It can be negative or positive in high-income counties, is always negative in middle-income countries, and is insignificant in low-income countries. Their results are robust even when other control variables such as population size, economic growth, and urbanization are accounted for.

Ali et al. (2016) investigated the dynamic impact of income inequality on CO_2 emissions in Africa with data from 1984 to 2001. Employing heterogeneous panel autoregressive distributed lag techniques, they found that income inequality has a reducing effect on CO_2 emissions. Other control variables such as GDP per capita, trade openness, and urbanization have an increasing effect on CO_2 emissions.

Jorgenson et al. (2017) investigated the relationship between production-based carbon emissions and two measures of income inequality (the income share of the top 10 per cent and the Gini coefficient) using US state-level data from 1997 to 2012. They employed a time-series cross-sectional Prais–Winsten regression model with panel-corrected standard errors while controlling for both year-specific and state-specific effects. As a robustness check, a random effects model was also estimated. Their findings show that whereas the top 10 per cent income share has a significant positive effect on carbon emissions, the Gini coefficient is not significant. They noted that the significant positive effect of the top 10 per cent is in line with the political economy dynamics and Veblen effects, which emphasize the potential economic and emulative influence of wealth, while the non-significant effect of the Gini is inconsistent with the 'marginal propensity to emit' approach. GDP per capita, population size, and fossil fuel production, which were included as control variables, had positive and significant effects on carbon emissions. The effect of manufacturing as a percentage of GDP varies according to the model estimated.

Grunewald et al. (2017) examined the theoretical relationship between carbon emissions and income inequality using a panel data set on high-, upper-middle-, middle-, and low-income economies. Results based on a group fixed effects estimator show that increasing income inequality has a negative effect on carbon emissions in low- and middle-income economies, while the effect in upper-middle-income and high-income economies is positive.

Knight et al. (2017) analysed the effect of domestic wealth inequality on consumption-based carbon emissions for 26 high-income countries using data from 2000 to 2010. The analysis was based on the political economy theories that the political economic power which accompanies wealth concentration is a deterrent to pro-environmental actions and hence leads to increasing environmental degradation. Results from two-way fixed effects models show that the top decile of wealth share has a positive effect on carbon emissions in high-income countries.

Klasen (2018) showed an inverse relationship between inequality and emissions as inequality forces the poor to live carbon-neutral lives, since they depend mainly on biomass. However, the relationship is positive in richer countries. Therefore, in rich countries, emissions will fall if inequality declines.

Except for Knight et al. (2017), all the studies focused on income inequality with no attention to wealth inequality. However, it has been argued that wealth is more unequally distributed than income among other differences, as pointed out in the Introduction. Moreover, Knight et al. (2017) studied only high-income countries. Therefore, an analysis of the relationship between wealth inequality and carbon emissions in emerging countries is warranted. This is the gap the current study seeks to fill.

3 Methodology

The study used a balanced panel dataset of annual observations from 2000 to 2014 for the BRICS countries. The start date was determined by the availability of the wealth inequality data, the end date by the availability of CO_2 emissions data. The dependent variable, CO_2 emissions per capita, was sourced from the World Development Indicators (World Bank n.d.). Wealth inequality is the main independent variable and is measured as the top decile of adults aged 20 and above—that is, the percentage of total wealth owned by the top 10 per cent of wealth holders. The top 10 per cent shares of wealth were obtained from Shorrocks et al. (2014), who used data on individual net worth—that is, the marketable value of financial and non-financial assets (mainly housing and land) less debts—from household balance sheets (HBS), regression estimates, and/or Forbes rich lists to estimate the cumulated shares of wealth (i.e. Lorenz curve ordinates) for each country. The Forbes rich list was used to ensure that the extreme upper tail of the distribution of wealth was accurately captured (Shorrocks et al. 2014).

'Complete' financial and non-financial balance sheet data are available for a number of countries, including South Africa, for at least one year. Another set of countries, including Brazil and Russia, have incomplete data—that is, financial balance sheets but no details of real assets. For these countries, regression-based estimates of non-financial assets were obtained. Where HBS data were unavailable, household survey data were used. Survey evidence on wealth is available for a few countries without HBS data, including China and India. India's data were characterized by very high shares of non-financial wealth and low debts, which reflect poor financial development.

In terms of quality, Shorrocks et al. (2014) summarized the data using a five-point scale from very poor to satisfactory. All the BRICS countries were rated as fair (3 points), implying that although they may not have HBS data, they have household wealth survey or other wealth distribution data such as estate or wealth tax sources.[1]

Control variables included GDP per capita, population, and domestic credit to the private sector—a proxy for financial development. These were also sourced from the World Development Indicators (World Bank n.d.). Prior to analysis, the variables were log transformed to enable the regression estimate to be considered as elasticities and hence interpreted in terms of percentages.

Both fixed and random effects panel models were estimated. The distinction between the fixed and random effects models has been clearly explained in the literature (Baltagi 2001; De wet and van Eyden 2005; Greene 2000). Fixed effect models control for group heterogeneity through the inclusion of an individual-specific intercept term. Fixed effects ensure that a more representative estimate is obtained, as they reflect political, economic policy, and institutional differences that are not explicitly modelled but are accounted for while estimating. Random effects models, on the other hand, assume that these effects are generated by a specific distribution—that is, cross-section differences are acknowledged by random effects but not explicitly modelled. Therefore, random effects models preserve loss of degrees of freedom, unlike fixed effects models. Random effects models also provide the opportunity to include time-invariant explanatory variables by assuming an uncorrelated entity's error term. According to Greene (2008: 183), 'the crucial distinction between fixed and random effects is whether the unobserved individual effect embodies elements that are correlated with the regressors in the model, not whether these effects are stochastic or not.'

The fixed effects model is specified as follows:

$$Y_{it} = \beta X_{it} + \phi_1 Z_{it} .....\phi_k Z_{it} + \alpha_i + u_{it} \quad (1)$$

where α_i is the unknown intercept for each entity (that is, fixed effects), Y_{it} is the dependent variable (CO_2 emissions) for each *i* entity (at time *t*), X_{it} is the main variable of interest, wealth inequality (wealth share of top 10 per cent), Z_{it} are the control variables (GDP per capita, population, and domestic credit to the private sector), β and ϕ_1 to ϕ_k are parameters to be estimated, and u_{it} is the error term.

The random effects model is specified as follows:

$$Y_{it} = \beta X_{it} + \phi_1 Z_{it} .....\phi_k Z_{it} + \alpha + u_{it} + \varepsilon_{it} \quad (2)$$

where u_{it} is the between-entity error term, ε_{it} is the within-entity error term, and all other variables are as previously defined.

4 Results

The descriptive statistics for the logarithmic form of the variables used are presented in Table 1. Population (POP) has the largest mean value (19.49) followed by GDP per capita (10.55), while carbon emissions (CO_2) has the least mean value (1.42). CO_2, wealth share of the top 10 per cent

[1] More details about the wealth shares data can be obtained from the Credit Suisse Research Institute's *Global Wealth Reports*, available at: https://www.credit-suisse.com/about-us/en/reports-research/global-wealth-report.html.

(TOP10), and financial development (FD) are skewed to the left, while GDP and POP are skewed to the right. GDP and FD series are normally distributed while carbon emissions, TOP10, and FD are not.

Table 1: Descriptive statistics of variables in log form

	CO_2	TOP10	GDP	POP	FD
Mean	1.427	4.229	10.548	19.491	4.123
Median	1.674	4.250	10.707	19.068	3.949
Maximum	2.548	4.440	13.329	21.034	5.076
Minimum	-0.033	3.884	7.480	17.638	2.613
Std. Dev.	0.881	0.121	1.654	1.275	0.669
Skewness	-0.241	-1.236	0.051	0.019	-0.111
Kurtosis	1.476	4.186	2.343	1.479	1.821
Jarque-Bera	7.986	23.497	1.382	7.231	4.501
Probability	0.018	0.000	0.501	0.027	0.105

Source: author's construction.

The results from the fixed and random effects models are presented in Table 2.

Table 2: Estimates of fixed and random effects models

	(1)	(2)
VARIABLES	**Fixed effects**	**Random effects**
TOP10	0.8526**	-5.9417***
	(0.0120)	(0.0000)
GDP	0.6621***	0.6035***
	(0.0000)	(0.0000)
Population	0.4882**	-0.2819***
	(0.0249)	(0.0000)
FD	-0.1590***	0.5886***
	(0.0001)	(0.0000)
Constant	-18.0224***	23.2550***
	(0.0000)	(0.0000)
Observations	75	75
R-squared	0.9169	0.6460
F-Stat/Wald Chi2	182.03*** (0.000)	127.72*** (0.000)
Number of id	5	5
Individual FE	YES	YES
Hausman test	69.18 (0.000)	

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

Source: author's construction.

As the F-test in column 2 is statistically significant, the null hypothesis that there are homogeneous cross-sections is rejected, thereby supporting the presence of these effects. Similarly, the significance of the Greene (2000) Wald test suggests that the null hypothesis of absence of cross-section heterogeneity be rejected in favour of the random effects specification. However, the choice between fixed and random effects models requires that the Hausman specification test, whose null hypothesis is that the preferred model is random effects and the alternative is fixed effects, be conducted (Greene 2008). The rejection of the null hypothesis favours the use of the fixed effects specification. Results of the Hausman test are presented in Table 2 and show that the fixed effects panel model should be selected.

Looking at the fixed effects estimates, it is observed that the main variable of interest, the percentage of total wealth owned by the top 10 per cent of wealth holders (TOP10), is positively and significantly related to carbon emissions. The results show that a 1 per cent increase in TOP10 will result in about a 0.85 per cent increase in carbon emissions, after controlling for the level of economic development, population size, and financial development. The elasticity coefficient of wealth inequality (0.85) is consistent with the Knight et al. (2017) value of 0.795 for high-income countries for the entire period of analysis and with values ranging from 0.672 to 0.84 for the 2000–2010 period. The positive elasticity coefficient of 0.85 implies that wealth inequality increases carbon emissions in the BRICS countries. This finding is consistent with the Boyce (1994, 2003, 2008) and Downey (2015) political economy framework, which argues that wealth gives political power to its holders. Since the wealthy, who are the principal beneficiaries of environmental degradation, are more powerful than the poor, who mainly bear the costs or consequences of environmental degradation (through, for example, their proximity to industrial activities), increasing wealth inequality will lead to increased environmental degradation (carbon emissions in our case). This is because the interests of the wealthy are protected in the political realm (Cushing et al. 2015), which gives them the privilege to create institutions, organizations, and networks that enable them to achieve their goals (which may not be environmentally friendly). In other words, the position of the wealthy creates avenues that make it possible for them to divert attention away from their environment-degrading activities, thus limiting pro-environmental behaviours (Downey 2015; Downey and Strife 2010) and policy actions.

The results are also consistent with the Veblen effect, which emphasizes the emulative influence of the wealthy. In other words, increasing inequality can make individuals consume more status-based goods and fossil fuels as they try to emulate the 'overconsuming' wealthier members of society (Schor 1998; Veblen 1934). Individuals may compete by purchasing large homes that lead to high energy use (Dwyer 2007; Frank 2010) or powerful motorized vehicles or by engaging in long-distance travel, which generates large emissions.

As regards the control variables, the results show that GDP per capita and population have positive and significant effects on wealth inequality, while financial development has a negative effect. This implies that a 1 per cent increase in GDP per capita (population) will lead to a 0.66 per cent (0.49 per cent) increase in carbon emissions, while a similar increase in financial development leads to a 0.16 per cent decrease in carbon emissions. These results point to a trade-off between carbon emissions and economic growth goals, whereas financial development has a pro-environmental effect. If the production of output depends on extensive use of energy, rising GDP will result in increasing environmental degradation. Similarly, if the organization of urban areas is environmentally unsustainable, for instance because of excess energy and natural resource consumption, a growing population could lead to rising carbon emissions (Jorgenson et al. 2017). Moreover, countries with large populations will tend to have higher expenditures on transport and communications, which could lead to higher per capita carbon emissions. Rapid economic growth could trigger industrialization and urbanization, which could directly accelerate energy consumption and CO_2 emissions (Zhang and Zhao 2014).

There have been mixed findings and explanations regarding the effect of financial development on carbon emissions. One school of thought holds that financial development reduces credit constraints, which enhances the expansion of economic output and increases the consumption of energy, leading to higher emissions (Dasgupta et al. 2001; Sadorsky 2010). Another school of thought maintains that financial sector development reduces carbon emissions, since it spurs investment in energy-efficient technologies (Frankel and Romer 1999; Shahbaz et al. 2013a, 2013b, 2013c). The reducing effect of the financial development variable in the current study could therefore be explained by the fact that financial development promotes access to funds for purchasing environmentally friendly technologies. This result is consistent with Shahbaz et al. (2013a, 2013b, 2013c) but contrasts with those of Abbasi and Riaz (2016) and Ali et al. (2019). Looking at these elasticities closely, one observes that wealth inequality has a larger effect on carbon emissions than the other variables.

5 Conclusion

The study investigated the relationship between wealth inequality and CO_2 emissions for the BRICS countries using the panel data approach. The fixed effects results show that wealth inequality, GDP per capita, and population have positive effects on CO_2 emissions, while financial development has a negative effect. This implies that the greater the gap between the top and bottom wealth classes, the more the BRICS countries will generate CO_2 emissions. Similar conclusions apply to GDP per capita and population. However, improving the financial instruments could assist in CO_2 emissions reduction. What is clear is that the concentration of income at the top of the distribution is a significant contributor to environmental degradation. The wealthy have their fortunes in fossil fuel industries and hence benefit disproportionately from environmental pollution.

This finding is consistent with the political economy approach and the Veblen effect, which emphasize the economic and political power as well as the emulative influence of the wealthy. It also has important policy implications. While policies are geared towards environmental safety, efficiency, and improvements, the social aspect in terms of reducing wealth inequality cannot be overlooked. This is because policies that redistribute wealth, ceteris paribus, would reduce CO_2 emissions and hence enhance environmental quality.

Looking at South Africa, for instance, it is notable that several social policies have been pursued to change economic and spatial structures that have given rise to high inequality levels since the colonial and apartheid era. However, these have not yielded the expected results. At the same time, South Africa has large energy-producing and mining industries, whose existence is due to surplus coal resources and subsidized coal-fired electricity. This places South Africa among the most carbon-intensive countries in the world. The government recently introduced the Carbon Tax Act, with effect from 1 June 2019, to ensure that the adverse costs (externalities) of carbon-emitting firms and consumers are accounted for in their future production, investment, and consumption decisions. The carbon tax is applied at the rate of ZAR120 (US$7.80) per ton of carbon dioxide-equivalent greenhouse gas emissions, while firms that adopt clean technologies are incentivized. Clearly, while the carbon tax policy was not introduced with the direct aim of reducing inequality, the findings of this study suggest that such policies, complemented by existing social policies, could greatly reduce wealth inequality in South Africa. It is therefore recommended that other emerging economies emulate South Africa and pursue both social and mitigation policies concurrently.

When designing carbon emission policies, level of wealth, GDP per capita, and population are important factors to be considered, since these all affect carbon emissions. Investing more in financial development is also recommended, since this has a reducing effect on wealth inequality. The need for pro-poor, inclusive economic growth and low-carbon development policies is supported by these findings, as is the combination of equality-enhancing and emissions-reducing policies. These might take the form of a wealth tax, a financial transaction tax, or emissions permits alongside a carbon tax like South Africa's.

These considerations are crucial, given the urgency of reducing carbon emissions and at the same time transforming economies through inclusive growth focused on poverty and inequality reduction. In other words, the BRICS economies would do well to adopt an integrated approach to policy formulation and implementation by focusing on policies that are related to energy conservation, emissions reduction, and climate adaptation as well as inequality reduction.

Future research may consider conducting this analysis on a provincial level if data on this are available. Further, the use of individual tax administrative wealth data, if available, may be considered as an alternative for constructing wealth inequality.

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