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Carbon Inequality

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This report is part of a series of research studies into alternative energy pathways for the global economy. In addition to disseminating original research findings, these studies are intended to contribute to policy dialogue and public awareness about environment-economy linkages and sustainable growth. All opinions expressed here are those of the authors and should not be attributed to their affiliated institutions.

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Abstract

The causes and effects of climate change can be seen as an equity problem involving two global stakeholder groups: Carbon Legacy Economies (CLE), responsible for the majority of atmospheric greenhouse gas stocks; and Carbon Emergent Economies (CEE), who will be responsible for the majority of growth in greenhouse gas flows and an increasing share of future atmospheric greenhouse gas stocks. The evidence presented in this paper indicates that, despite their sizeable contribution to the growth of CO2 emission flows, rapid industrialization in developing countries will not significantly alter the balance in global carbon inequalities over the next two decades. In particular, rapid growth in fossil fuel CO2 emissions in CEE countries will not alter the fundamental imbalances in carbon stocks that divide CLE and CEE countries. This conjunction of environmental and economic evidence has profound implications for global climate negotiations.

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1. Introduction

At a fundamental level, the causes and effects of climate change represent an equity problem involving two global stakeholder groups:

- Carbon Legacy Economies (CLE): Those countries responsible for the majority of atmospheric greenhouse gas stocks, who will continue to represent a significant share of future greenhouse gas flows, sometimes referred to as 'developed countries'; and
- Carbon Emergent Economies (CEE): Those countries who will be responsible for the majority of *growth* in greenhouse gas flows and an increasing share of future atmospheric greenhouse gas stocks, including those referred to as 'developing countries.'

Despite mounting concern over rapid greenhouse gas emission growth in CEE countries, in this paper we argue that emissions growth will not fundamentally alter the carbon equity balance between CLE and CEE countries. Climate change is, and will continue to be, a problem caused predominantly by wealthy countries.

A useful device to visualize CLE-CEE carbon inequality is the Lorenz curve, a cumulative frequency distribution used in economics to illustrate income distribution and other equity variables. In the present context, "CO_2 emissions" or carbon Lorenz curves show the distribution of energy-related CO_2 stocks and flows among countries on an implied per capita basis, with the cumulative percent of energy-related CO_2 emissions on the y-axis and the cumulative percent of population on the x-axis, ranked by per capita income.[2]

Because of their per capita roots, Lorenz curves provide an important tool for considering equity in global climate negotiations. This paper elucidates the perspective of per capita emissions and incidence as a logical and ethical bases for global climate policy dialogue between North and South (Agarwal and Narain, 1991; Baer, 2002).

[2] All the Lorenz curves in this exposition use GDP per capita at purchasing power parity (PPP) to rank population along the x-axis.

Figure 1 provides an example of a CO_2 emissions Lorenz curve for 2004. The 45 degree line represents the line of perfect equality, where national CO_2 emissions are equalized globally on a per capita basis. The area between the line of perfect equality and the actual distribution (Lorenz) curve is termed the Gini coefficient of inequality, which we calculate here as

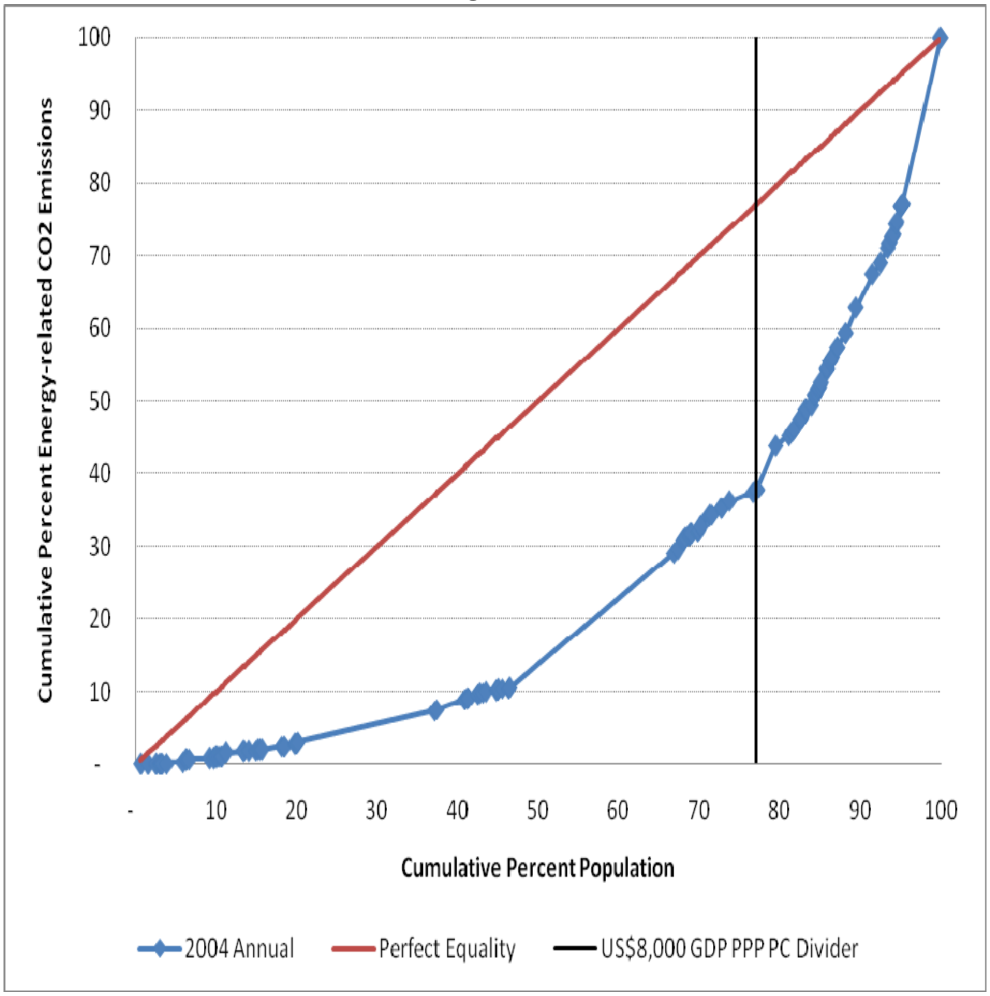
$$\sum_{i=0}^{n} \frac{100^2 - [(p_{i+1} - p_i)(e_i + e_{i+1})]}{100^2}$$

where p is the percentage total population for country i and e is the percentage total energy-related CO_2 emissions for country i. In this case the Gini coefficient indicates the degree of global inequality in per capita energy-related CO_2 emissions. A Gini coefficient of zero corresponds to perfect equality, while a theoretical Gini coefficient of one would indicate all emissions arise from one person.

The Gini coefficient in Figure 1 is 0.52. To put this, and the numbers below, in context, Brazil's Gini coefficient was 0.54 in 2004; Namibia has recently had the world's highest Gini coefficient at 0.71 in 2003 (UNDP, 2006; CIA, 2006). A potentially more intuitive way to interpret Figure 1 is that the 77 percent of the world's population with per capita GDP PPP of less than US$8,000, accounted for 38 percent of global energy-related CO_2 emissions in 2004, while the 23 percent with GDP PPP per capita of more than US$8,000 accounted for 62 percent of global energy-related CO_2 emissions.[3]

[3] We use US$8,000 as a dividing line between lower and higher income countries throughout this paper; in our data set this line separates Romania and Costa Rica.

Figure 1



Sources: Population, GDP PPP, and 2004 energy-related CO2 emissions data are from IEA (2006a); 1904-2004 cumulative emissions data are from CAIT (2007); CAIT cumulative data are updated to 2004 using IEA (2006a).

We use Lorenz curves to demonstrate two facts about global CO2 emissions, past, present, and future. First, from either a flow or stock perspective, carbon inequality is currently at levels that are unacceptable by international standards.[4] Second, even with significant — and more equitable — emissions growth in CEE countries over the next two decades, the fundamental imbalance in carbon stocks between CLE and CEE countries will not disappear.

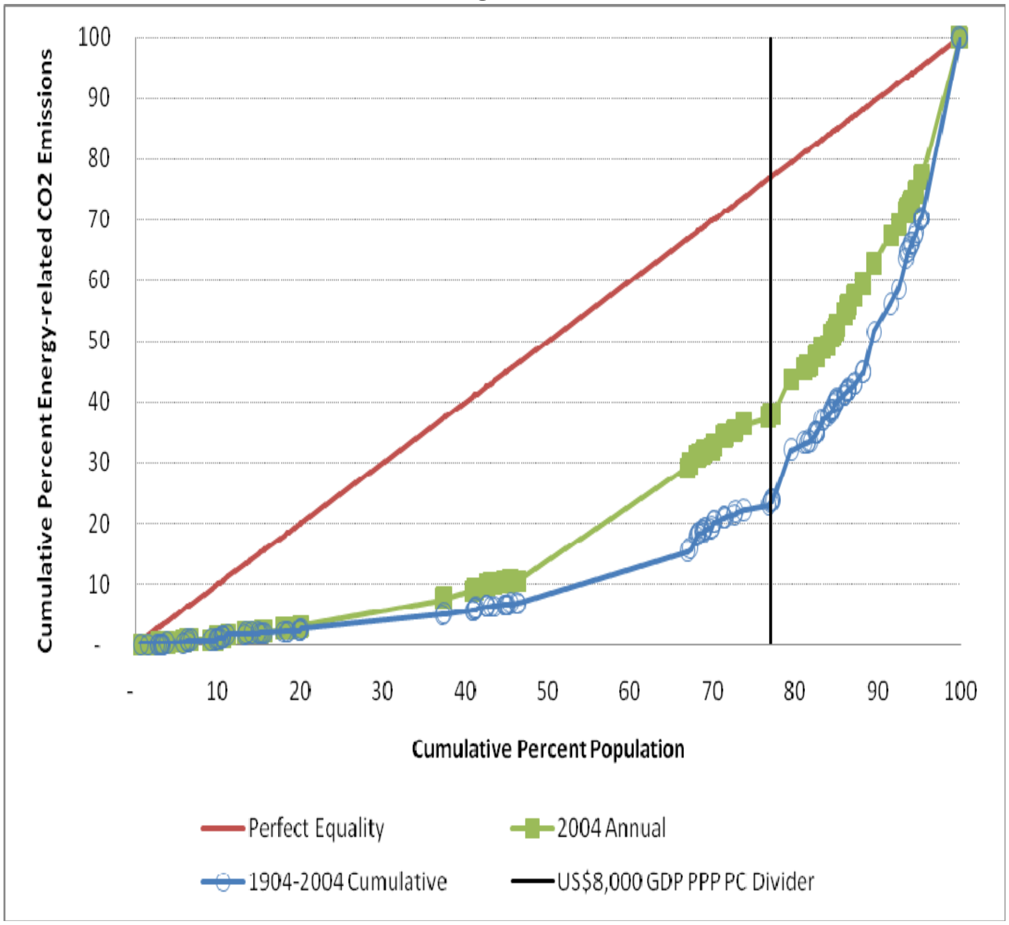
[4] The term "unacceptable" here is not normative, but means unlikely to sustain a global policy consensus.

2. 2004 CO_2 Emissions and 1904-2004 Cumulative CO_2 Emissions

Figure 2 shows the distribution of 2004 energy-related CO_2 emissions (flows) and cumulative 1904-2004 energy-related CO_2 emissions (stocks). By using a 100-year timeframe for the latter, we implicitly assuming a 100-year residence time for CO_2 in the atmosphere. Extending emissions back this far in time likely overestimates the share of industrialized countries' emissions, given that better data on primary energy use exists in these countries. Similarly, we do not include emissions from land use change in our Lorenz curves, which also biases them toward higher shares of emissions from industrialized countries (WRI, 2004). Nonetheless, given that climate change is driven in significant measure by the combustion of fossil fuels, Figures 2 and 3 provide a revealing perspective on the political economy of greenhouse gas emissions.

As noted previously, the 2004 Annual curve has a Gini coefficient of 0.52. Note now that 1904-2004 stocks are significantly more unequal than 2004 flows, i.e. the 1904-2004 Cumulative curve has a Gini coefficient of 0.64, placing it on par with the world's most income-unequal societies. Put differently, the 77 percent of the world's population to the left of our US$8,000 dividing line contributed less than 24 percent to the world's atmospheric stock of fossil fuel CO_2 emissions from 1904-2004, while 23 percent of the world's population to the right contributed more than 76 percent.

Figure 2



Sources: Population, GDP PPP, and 2004 energy-related CO_2 emissions data are from IEA (2006a); 1904-2004 cumulative emissions data are from CAIT (2007); CAIT cumulative data are updated to 2004 using IEA (2006a).

If conventional wisdom on the relationship between energy demand and economic growth is to prevail in the near term, convergence of incomes between developing and developed countries will require significant growth in per capita energy consumption and, without changes in the world's dominant reliance on fossil fuels, significant growth of per capita CO_2 emissions in developing countries.

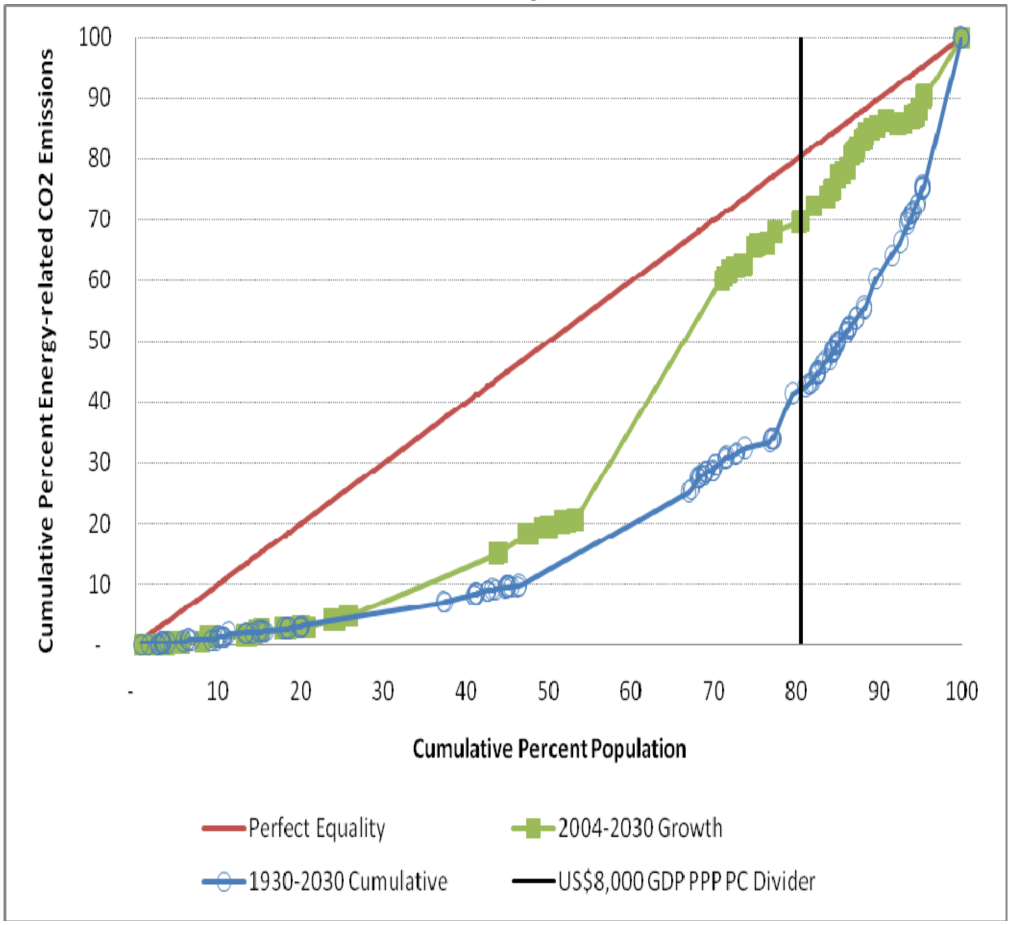
3. 2004-2030 CO_2 Emissions Growth and 1930-2030 Cumulative CO_2 Emissions

Figure 3 shows the distribution of projected 2030 energy-related CO_2 emissions and implied cumulative 1930-2030 energy-related CO_2 emissions, using the International Energy Agency's (IEA) reference scenario projections and updating cumulative emissions data to 2030. IEA (2006) projections are only available at an aggregate, regional level. To disaggregate regional totals by country, we assume that the national shares of 2004 regional emissions are the same as those in 2030. To calculate 2030 cumulative emissions, we assume an average, annualized growth rate in energy-related CO_2 emissions from 2004-2030. For the x-axis in Figure 3, we use 2030 population projections from the United Nations, but rank these by 2004 GDP PPP per capita.

As Figure 3 illustrates, 80 percent of the world's population to the left of the US$8,000 divider accounts for nearly 70 percent of the growth in annual energy-related CO2 emissions from 2004-2030. Because much of this emissions growth occurs in the world's most populous countries — China (the nearly vertical line dominating the middle of the figure) alone is projected to account for almost 40 percent of growth in annual energy-related CO2 emissions from 2004-2030 — the Gini coefficient on the 2004-2030 Growth curve is 0.33, comparable to income inequality in northern European countries.

Despite their sizeable contribution to the growth of CO2 emission flows, rapid industrialization in developing countries will not significantly alter the balance in global carbon inequalities over the next two decades. The CO2 stock share of the world's upper-income quintile (countries representing the 20 percent of the world's population to the right of the US$8,000 divider) falls from roughly 76 over 1904-2004 to 66 percent over 1930-2030. Because of its shrinking share of global population and the persistence of atmospheric carbon stocks, the 1930-2030 Cumulative curve Gini coefficient falls by only 4 percentage points (0.60) vis-à-vis the 1904-2004 Cumulative curve coefficient (0.64). In other words, rapid growth in fossil fuel CO2 emissions in CEE countries will not alter the fundamental imbalances in carbon stocks that divide CLE and CEE countries. This conjunction of environmental and economic evidence has profound implications for global climate negotiations.

Figure 3



Sources: 2030 Population data are from UN (2005); 2004 GDP PPP per capita data are from IEA (2006a); 2005-2030 energy-related CO_2 *emissions growth data are based on the reference scenario in IEA (2006b); 1930-2003 cumulative emissions data are from CAIT (2007); 2004-2030 cumulative emissions are based on an annualized average using IEA (2006b) reference scenario projections.*

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