Carbon Lorenz Curves revisited: Do the Paris Agreement and its Nationally Determined Contributions reflect a more equitable future emissions pathway?

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Abstract:

Climate change and its consequences threaten human development and lead to environmental inequality: The inequality is two-sided, both in terms of historic and current contribution to global emissions and how countries are impacted by the resulting climate change. This generated an important debate about historic responsibility of developed countries and the need for sustainable growth pathways for developing countries. This conference contribution looks into the equality dimension of the Paris Climate Agreement and its (Intended) Nationally Determined Contributions, (I)NDCs.

We use the Gini index and the Lorenz curves to assess the carbon equity performance of the (I)NDCs. We compare the Gini index of annual and cumulative national average per capita GHG emissions for the time frame 2015-2030 of conditional and unconditional (I)NDCs and set this into perspective with the recent evolution of GHG emissions equality. Our results show that the (I)NDCs, while not meeting the Paris temperature goal, lead towards a more equitable future, though at a slower rate and mostly attributed to efforts by developing countries.

Keywords: climate policy; carbon equity; national determined contributions; cumulative emission per capita; carbon Gini index, Lorenz curves

1 Introduction

Climate change and its consequences threaten human development and lead to environmental inequality: The inequality is two-sided, both in terms of historic and current contribution to global emissions and how countries are impacted by the resulting climate change. This generated an important debate about historic responsibility of developed countries and the need for sustainable growth pathways for developing countries. This conference contribution looks into the equality dimension of the Paris Climate Agreement and its (Intended) Nationally Determined Contributions, (I)NDCs (UNFCCC 2015, 2016).

2 Methodological Approach

The Gini index and its geometric interpretation as Lorenz curves (Lorenz 1905) measure income distribution between population groups, e.g. distribution of average per capita income of different countries, weighted by population. They have also been used as a measure of inequality other than income, such as per capita CO_2 emissions (e.g. Pan et al. 2014, Heil and Wodon 1997, Groot 2010, Pan, Teng, and Wang 2014b) and cumulative historic carbon emissions (Teng et al. 2011), reflecting historic responsibilities of developed countries. Pan et al. (2014) used this approach to analyze the level of equity of different emission allocation schemes.

We apply this approach to the Paris Climate Agreement, in form of the (I)NDCs, to assess their carbon equity performance and to derive implications for their first revision. We will compare the Gini index of annual and cumulative national average per capita GHG emissions (tCO_2e) for the time frame 2015-2030 for different (I)NDC scenarios (Meinshausen et al. 2016) and set this into perspective with the recent evolution of emissions equality. The two scenarios reflect condition (I)NDC-high and unconditional (I)NDC-low country pledges. To depict the differences, we use Lorenz curves.

3 Results

Figure 1 shows a Lorenz curve of national average annual GHG emissions (tCO_2e) per capita in 2014. The horizontal axis shows the cumulative population of countries ranked in ascending order of their average per capita GHG emissions. On the vertical axis, the respective GHG emissions are shown. If annual per capita GHG emissions were distributed equally worldwide, the Lorenz Curve would match the 45-degree line, and the Gini index would be 0 (perfect equality). The higher the Gini Index (max. 1), the further away is the Lorenz curve from the 45-degree line.

Figure 1 also shows the impact on the distribution of annual per capita emissions in 2030 and 2020, if conditional (I)NDCs are followed through compared to historic distributions. While great improvements in equality could be witnessed from 1990 (Gini 0.47) to 2000 (Gini 0.41) and even more in the following ten years to 2010 (Gini 0.35), the (I)NDC result in a slow-down in improvement of equity. The (I)NDC-high scenario pratically keeps the distribution of 2010 in 2030 (Gini: 0.34). While a decrease in over 24% was achieved from 1990 to 2010, the (I)NDCs only relate to a decrease of 3% ((I)NDC-high) and 13% (((I)NDC-low) in the following 20 years respectively.

As we are looking at differences between countries, one should not forget that big discrepancies within countries exist and are increasing. Emission rates in certain socio-economic strata in developing countries or emerging economies match the levels of average emissions in industrialized countries. It is estimated that within-country inequality explains 50% of global GHG emission inequality (Chancel and Piketty 2015). Average country values hence tend to mitigate the range of inequality in pollution contribution and further analyses should focus on individuals.

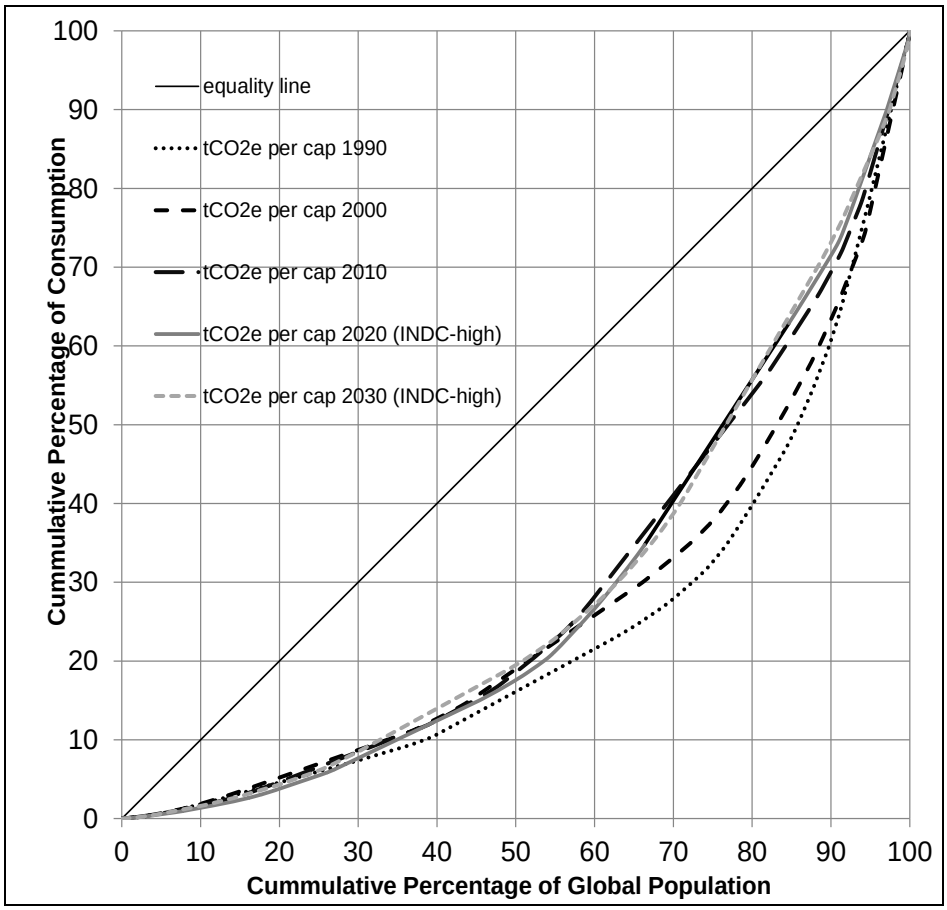

Figure 1 Lorenz Curve for per capita GHG emissions (tCO_2e) for given years: 1990, 2000, 2010 based on historic data and 2020 and 2030 based on high INDC-scenario

Furthermore, the Gini coefficient and Lorenz curve do not provide information on the level of pollution. Global average annual per capita GHG emissions as laid out in the (I)NDCs are expected to be 6.7 (6.4 to 7.2) tCO_{2e}/capita in 2030 (UNFCCC 2015), similar to the current value of around 6.5 tCO_{2e}/capita. Yet, the global median is expected to decrease from currently 5.2 to 3.6 ((I)NDCs-high) and 4.3 tCO_{2e}/capita ((I)NDC-low) (Figure 2).

The difference between the two (I)NDC scenarios is mainly related to the conditional pledges of developing countries. Without those, global annual mean per capita GHG emissions would even increase. The current (I)NDCs are not sufficient to fulfill the temperature goal of the Paris Agreement and are expected to lead to a temperature increase of around 2.7 °C (UNFCCC 2015).

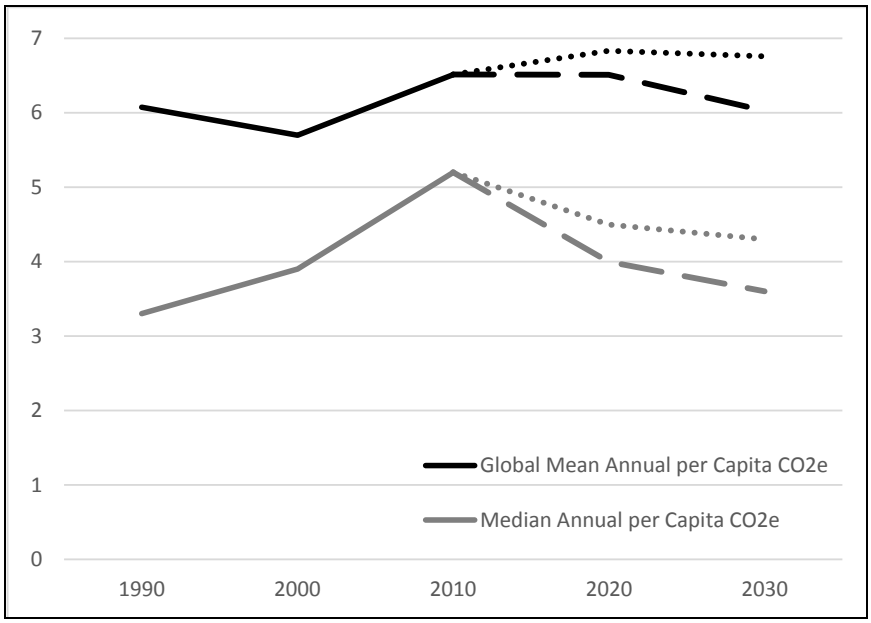

Figure 2 Changes in global mean and median annual per capita GHG emissions (tCO_2e). (I)NDC-low: points, (I)NDC-high: dashed

The (I)NDC-low scenario (2030 Gini: 0.31) is more equal than the (I)NDC-high scenario (Gini: 0.34) as the developing countries through their conditional pledges achieve a higher ambition level then developed countries (Robiou du Pont et al. 2017). These discrepancies are to a large extent due to India's increased ambition in the high-scenario which reflects its conditional pledges (Figure 3). In the latter, India (18.1% of global population in 2030) represents only 10% of global GHG emissions vs 11.6% in the unconditional scenario, up from 7% in 2010. It can be seen that at in the tails of the Lorenz curves not much changes. China, with 17% of global population, practically keeps the same share of global GHG emissions in both cases: 29%, up from 25.3% in 2010 which is why the Lorenz curves are parallel from 70% of cumulative population onwards.

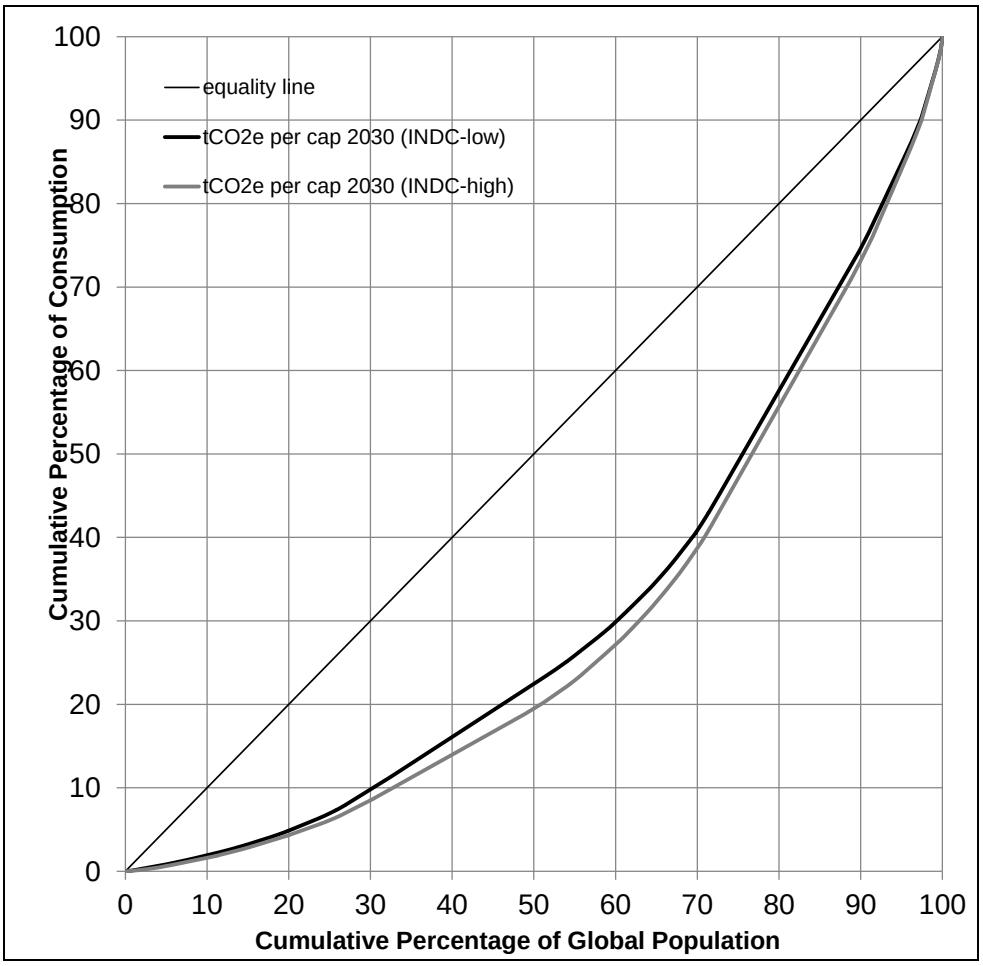

Figure 3: Lorenz Curve for per capita GHG emissions (tCO_2e) in 2030 for two INDC scenarios.

Figure 4 shows for select countries their share in global emissions versus their share in global population. By 2020, with global convergence China will overtake Germany, increasing its emission share in relation to its global population share. By 2030, in the unconditional scenario, Germany will nearly reaches a factor of 1. While the difference in per capita emission is larger for the US than for India between scenarios, the latter results to a large cumulative difference due to its population size.

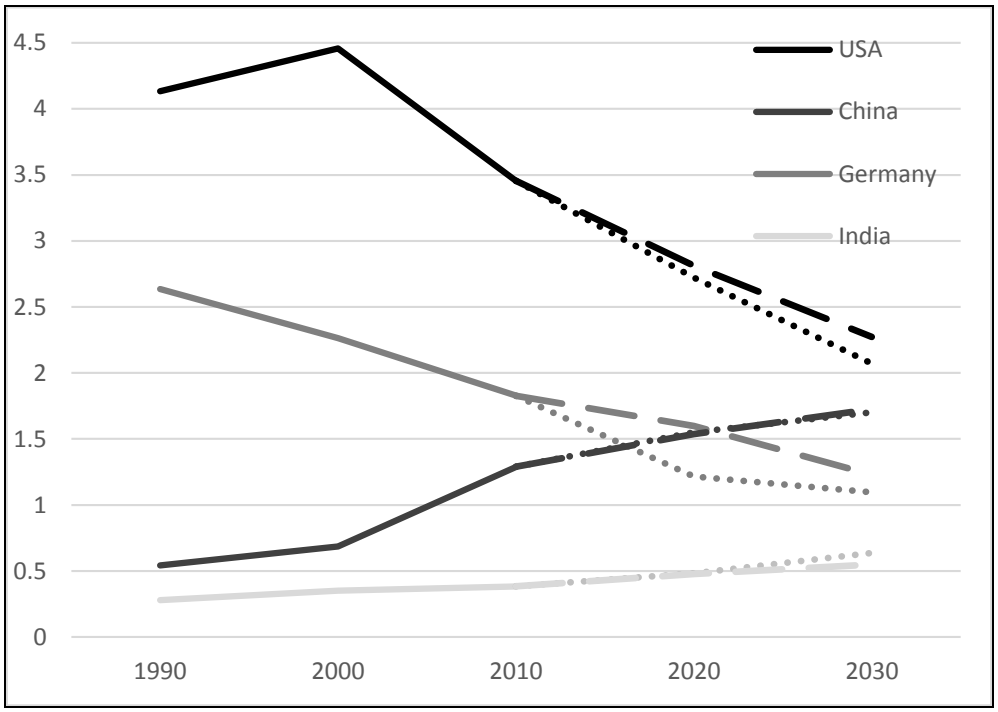

Figure 4 Factor of share (%) in global per capita GHG emissions vs share (%) in global population for select countries, (I)NDC-low: points, (I)NDC-high: dashed

To assess the dimension of cumulative equity changes of the Paris agreement and its (I)NDCs we now look into the Lorenz curve (Figure 5) for cumulative per capita emissions in the 15 years prior to Paris and the 15 years of the first (I)NDCs, as most (I)NDC set 2030 as their time horizon. For both time spans, national average per capita GHG emissions where calculated based on the mid-term population.

As Figure 5 shows, in the lower 60% of the population, the (I)NDC-high scenario matches the 15 years before Paris in terms of equity. For the lowest 30% of population, the (I)NDC-high scenario is even slightly more inequitable. Also cumulatively, the difference between the two scenarios is due to India's pledge.

The majority of shift in the Lorenz curves closer to the line of equity from pre- to post-Paris is again due to China which is basically catching up with developed countries. The cumulative Gini decreases from 0.38 (2001-20150 to 0.32 (2016-2030 (I)NDC-low) and to 0.34 (2016-2030 (I)NDC-high) respectively. When looking at the country rankings, one can see larger shift for developing countries between the two scenarios.

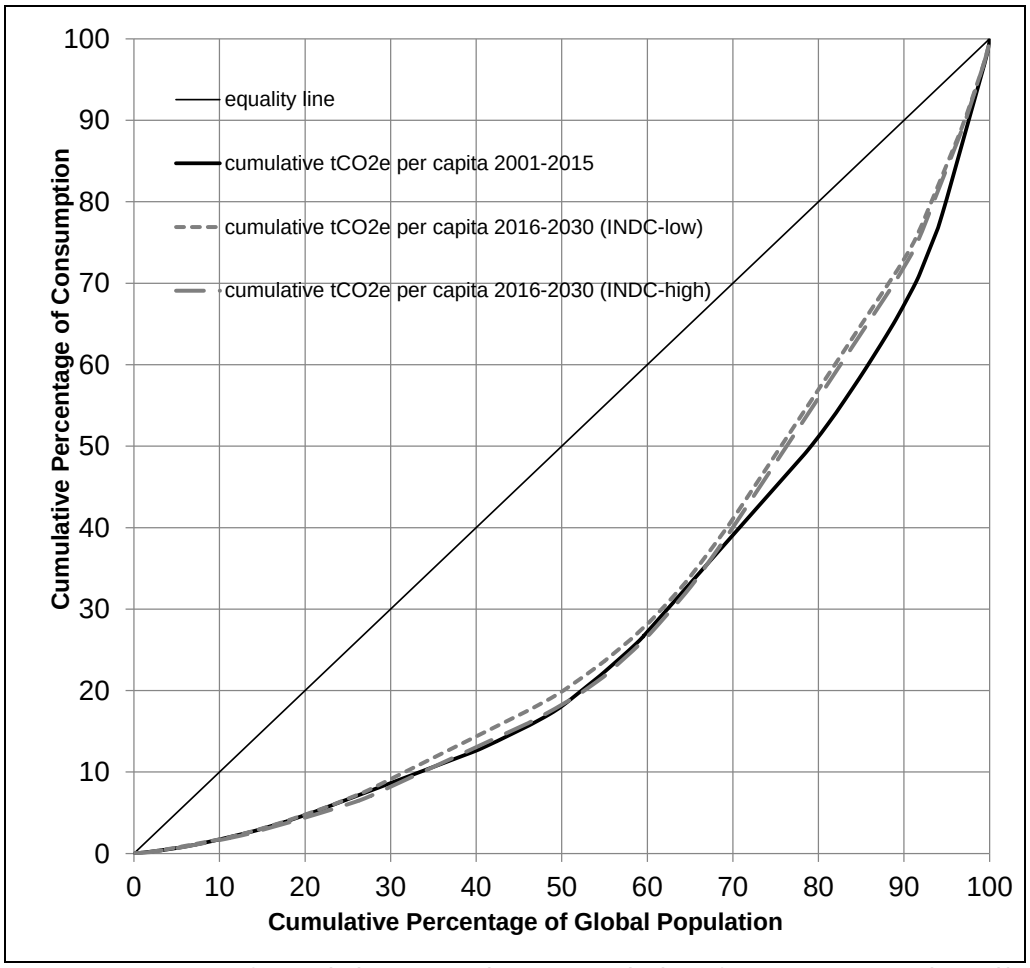

Figure 5 Lorenz Curve of cumulative per capita GHG emissions for 2000-2015 and two (I)NDC scenarios for 2016-2030

4 Conclusion

We have shown that the (I)NDCs lead towards a more equitable future, though at a slower rate. At the same time, carbon equity is still far away. The Paris Climate Agreement brought about a novel global climate governance with new roles and responsibilities. The (I)NDCs and their role in the agreement show an increasing interest of Parties in this paradigm shift which is supported by the increasing emission equity. The dichotomy of developed and developing countries does not dominate the discussions anymore with developing countries becoming more empowered and active actors in climate mitigation, more than developed countries. This is reflected in lower equity levels when looking at the conditional (I)NDCs. As no sanctions for not meeting ones (I)NDCs are envisaged with the system relying on the intrinsic motivation of the countries, the global community has embarked on a moral trial ground, motivated by cooperative spirit.

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