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"The Political Economy of the Paris Agreement. Income Inequality and Climate Policy"

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Abstract

We empirically assess how both between-country inequality and within-country inequality relate to climate policy ambition as defined by NDC pledges of the Paris Agreement (COP21). We exploit the difference between high and low ambition targets submitted by parties to construct a climate policy ambition index. We find that both inequalities shape countries' pledges: First, low income countries tend to be more ambitious in setting their pledges when external support is received. Second, within-country inequality is associated with (i) lower mitigation ambition in low and middle-low-income countries, and with (ii) higher mitigation ambition, although none statistically significant, for upper-high and high-income countries. Despite we cannot claim any causal mechanism, our results are discussed in terms of climate policy being a superior good in rich countries and elites benefiting from emitting economic activities in poorer countries

JEL classification: F53, O57, P16, Q58

Keywords: Climate Policy, Inequality, Paris Agreement, COP21, INDC

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Acknowledgements

1. Introduction

The Paris Agreement, reached in 2015, is widely considered to be one of the most important milestones in global climate policy: 195 very different countries, facing very different pressures within their borders and very different responsibilities as regards climate change and its impacts, committed themselves to keeping the global temperature rise this century well below 2 ºC. Each country submitted a nationally determined pledge, or nationally determined contribution (NDC), to reduce greenhouse gas (GHG) emissions by 2030. Importantly, most countries submitted two NDCs, one of them more ambitious than the other, conditional on their receiving external support (financial, technological and/or capacity building) from other countries. Against this backdrop, the main objective of this paper is to analyze how cross-country income differences, as well as within-country income inequality, shape the climate policy ambition of these 195 countries.

The relationship between income inequality and environmental deterioration has been previously addressed by several studies with somewhat contradictory conclusions, as is evident in the literature review conducted by Berthe and Elie (2015). From a theoretical point of view, we find, on the one hand, a stream of literature based on the economic behavior of households. For example, Scruggs (1998) and Heerink, Mulatu and Bulte (2001) consider environmental quality a superior good, so that demand for environmental protection grows as income increases. In this context, more affluent households, it is claimed, are more willing to replace environmentally damaging goods with environmentally friendly goods, even if this means a higher monetary cost. On the other hand, we find a stream of literature that finds a negative relationship between inequality and environmental quality. For example, Boyce (1994) contradicts the notion that affluent people favor environmentally friendly policies; on the contrary, he claims they favor environmentally damaging activities and, because inequality results in the concentration of political influence in the richest segment of society, they will oppose environmentally friendly policies. In a similar vein, Magnani (2000) argues that inequality means less power in the middle segments of society and this results in lower pressure for environmental protection.

The empirical evidence on the relationship between inequality and environmental degradation is, to date, inconclusive. Contradictory results are to be found in such seminal studies as those by Torras and Boyce (1998), who find income inequality to be positively related to air pollution, and Ravallion, Heil and Jalan (2000), who find a negative relationship between inequality and carbon dioxide emissions. Subsequent studies on the relationship between income inequality and CO2 emissions sow further seeds of doubt. Thus, whereas Baek and Gweisah (2013) and Uzar and Eyuboglu (2019) find a positive relationship, Heerink, Mulatu and Bulte (2001) find a negative relationship. For their part, Liu, Yiang and Xie (2019) find that inequality increases CO2 emissions in the short term and reduces them in the long term, while Clément and Meunié (2010) find no significant relationship. Interestingly, Grunewald et al. (2017), in a study that distinguishes between low-, middle-, and high-income countries, find that in low- and middle-income economies inequality is negatively associated with CO2 emissions, while the opposite is the case in upper-middle and high-income economies, where greater inequality increases emissions.

While there is a growing body of evidence on the relationship between social inequality and emission levels, the literature on the potential effects of income inequality is much rarer. More specifically, we are unaware of any previous empirical analysis of the effect of income inequality on climate policies, as defined under the Paris Agreement.[1] Here, to study how cross-country, as well as within-country, income inequality might shape the climate policy ambition of different countries, we draw on different inequality indices as we seek to capture how inequality (or which kinds of inequality) affects climate policy. Our results suggest that the lower the country's income, as measured by GDP per capita, the greater is its ambition in the presence of external support. Within-country inequality, as measured by different indices, is associated with lower mitigation ambition. This relationship holds for low- and middle-low-income countries, but we find no significant relationship between inequality and mitigation ambition for high-income countries.

2. The Paris Agreement and the (I)NDCs

In December 2015, the United Nations Framework Convention on Climate Change (UNFCCC) Conference of the Parties (COP21) was held in Paris. Before this, the state parties had been invited to outline publicly their plans as of 2020 for addressing climate change, in what was known as their intended nationally determined contributions (INDCs). Subsequently, these plans were formally submitted to the Paris Agreement and ratified as the parties' NDCs.

Each State's NDC lays out its commitment to achieve the long-term goals set out under the Paris Agreement, essentially, that is, to maintain the global temperature rise below 2 ºC, or ideally below 1.5 ºC (IPCC, 2018). However, it is well documented that these pledges have fallen short. Indeed, according to various studies (including, UNEP 2017, IEA 2016, CAT 2018), current NDCs put global temperatures on track to rise at 2.7–3.7 ºC over pre-industrial levels over the next century (median chance).[2]

In contrast to the Kyoto Protocol, the Paris Agreement adopts a bottom-up architecture. Thus, countries are free to set their mitigation targets and they are accountable for achieving them. However, as this is insufficient to reach the global target, every five years, a global stocktake (Article 14 of the Paris Agreement)[3] is conducted during which the countries NDCs are assessed and, depending on the outcome, they are expected to update or enhance their targets. The First Global Stocktake is to be held in 2023 and is meant to result in revised NDCs by 2025.

One of the main obstacles faced by the Paris architecture is the measurement and comparison of mitigation efforts across countries. The discretion afforded countries to determine their own mitigation efforts resulted in a variety of targets that are not always readily comparable: some of these targets refer to historical emission levels, while others refer to business-as-usual (BAU) emissions. Likewise, some express their targets as emissions per capita, while others refer to emissions per gross domestic product (GDP). These complications, together with many other assumptions in the countries' NDCs, blur cross-country comparability, which in turn undermine perceptions of equity and make free-riding more probable (Barrett 2003). For instance, while we know a country's emission

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[1] Zimm and Nakicenovic (2019) analyze the implications of the Paris Agreement for inequality, but their analysis refers to inequality in the effort to control emissions, rather than to economic inequality.

[2] MIT https://www.wri.org/blog/2015/11/latest-climate-commitments-how-much-will-world-warm-its-complicated

[3] Article 14 of the Paris Agreement provides for a periodic global stocktake "of the implementation of this Agreement to assess the collective progress towards achieving the purpose of this Agreement and its long-term goals". This stocktake is to conducted in a "comprehensive and facilitative manner, considering mitigation, adaptation and the means of implementation and support, and in the light of equity and the best available science".

levels in 2030 based on the NDC it submitted, it tells us very little about the level of effort required of it, i.e. whether the country is excelling itself or free-riding on others. The long-term success of the Agreement may well depend on just how this problem of comparability is addressed, that is, determining whether similar countries are actually making a comparable effort (Aldy and Pizer 2016; Aldy et al. 2016; Aldy et al. 2017).

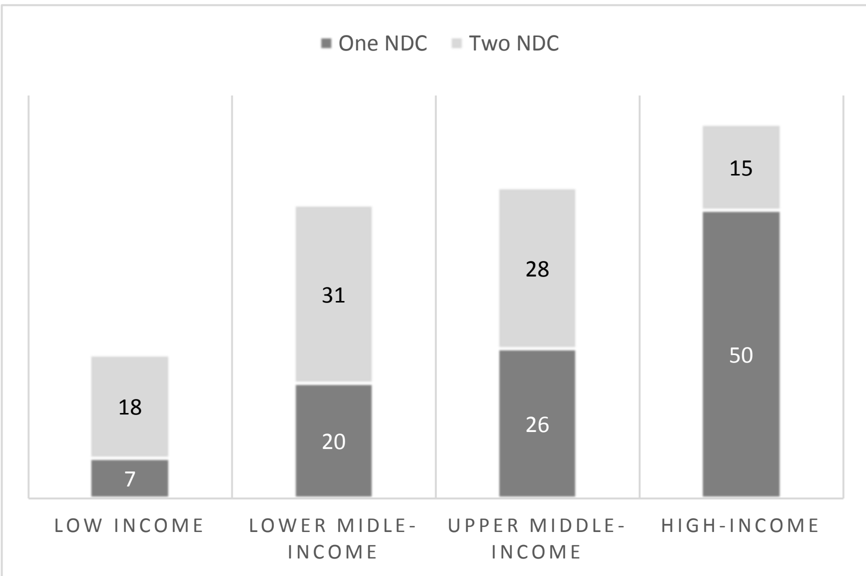
In this paper, we exploit the fact that countries were able to submit two types of NDC: a low-ambition and a high-ambition target. The former identifies the mitigation targets that a country plans to achieve using its own resources; the latter, in contrast, is more ambitious in reducing emissions albeit conditional on receiving external support, in the form of finance, technology or capacity building. The difference between the two gives us a sense of the additional effort a country is willing to make as it moves from its current circumstances (own means) to the most favorable circumstances (external support). Thus, we are specifically interested in disentangling which factors spur or block climate policy ambition, and, especially, in shedding light on the role played by inequality.

3. Data and methods

3.1 Climate policy ambition

The (I)NDC data are taken from the Australian-German Climate and Energy College (Meinshausen and Alexander 2017), the only portal to date that provides a comprehensive overview of all the NDCs with the corresponding quantification of country's planned emissions. For all countries, we have information about the levels of GHG emissions that they commit to in 2030. Some countries record two NDCs – corresponding to low/high ambition targets, while others record just one NDC – these tend to be the richer countries, whose NDCs are not dependent on external support (Figure 1).

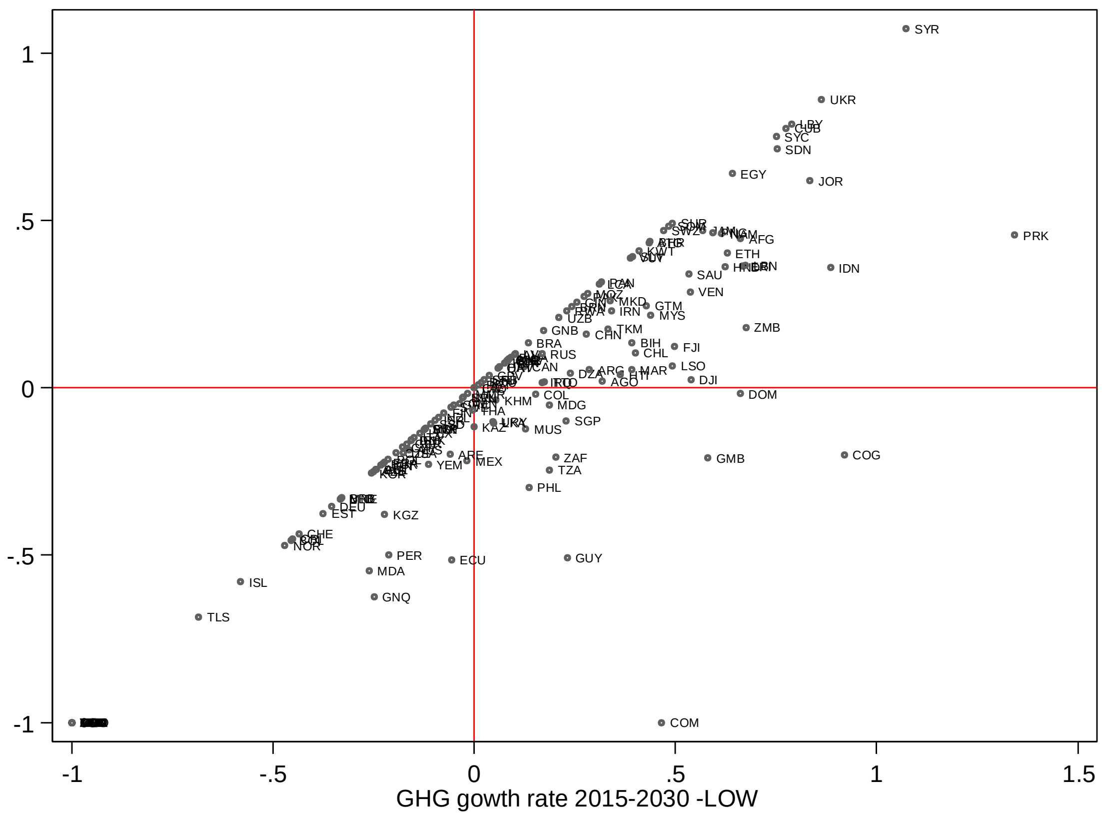
Figure 1. Number of countries with one or two NDCs by World Bank categories income level (195 countries in total; 92 have two NDCs).



Source: Own elaboration

The level of ambition expressed by some countries increases if they can count on external support. Figure 2 shows the expected growth rate in GHG emissions between 2015 and 2030 associated with high- (Y axis) and low-ambition targets (X axis). Taking the levels of emission for 2015, some countries – those in the bottom-left quadrant – plan to reduce their emissions no matter what. Others – those in the top-right quadrant – and independent of external support, show an increase in their GHG emissions compared to emissions levels for 2015. Finally, the countries in the bottom-right quadrant will only reduce their level of emissions if external support is received.

Figure 2. GHG emission growth rate 2015-2030 according to high and low ambition NDCs



Source: Own elaboration

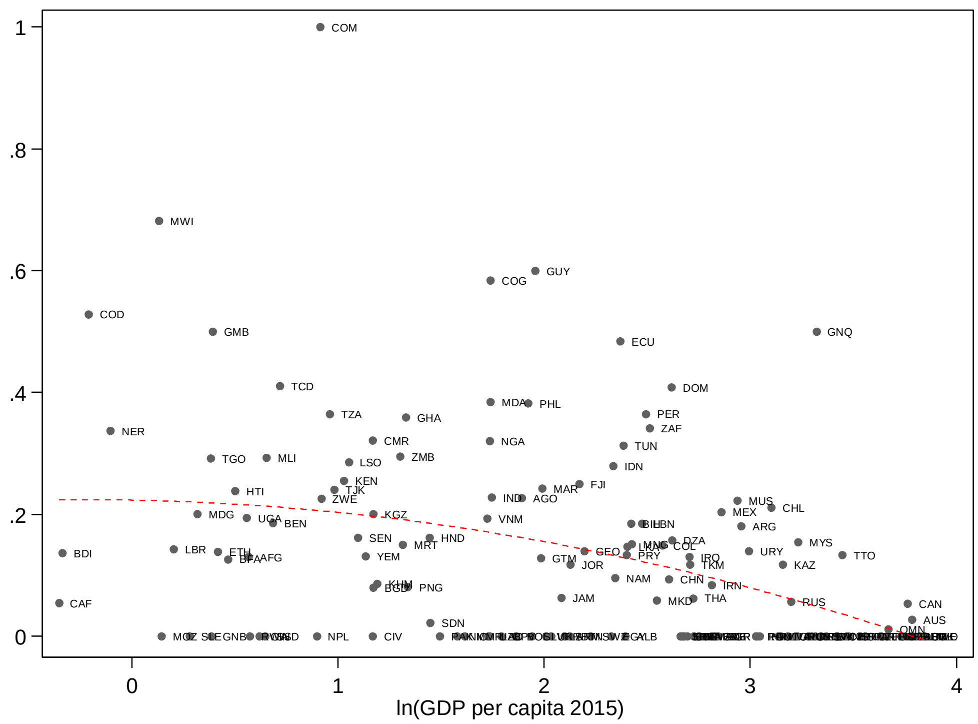
On the basis of this, we might speculate that only the countries in the bottom-left show any real mitigation effort and that those in the top-right are free riding on the former. However, this would be naïve as country's mitigation effort is considerably more complex than this. For example, a country may increase its annual emissions in 2030, yet the level it records may well imply a huge effort in terms of their own means.

If we consider how far countries lie from the diagonal, a different story emerges from Figure 2. Countries on the diagonal are those that have submitted just one NDC and, hence their low- and high-ambition pledges are one and the same. In contrast, the further a country lies from the diagonal, the greater is the difference between its low- and high-ambition pledges. For instance, the Republic of Congo (COG) reports it will increase its annual emissions rate by 0.9% in 2030 (compared to 2015 levels) if no external support is received (low ambition). Yet, with external funding, it undertakes to reduce its 2030 emission levels by -0.2% (compared to 2015 levels). Likewise, India (IND), with a similar GDP per capita to that of COG in 2015, reports it will increase its emissions by 1.35% or, if external support is received, the increase will be 0.81% higher than the level recorded in 2015. Which country is making a greater mitigation effort? The answer depends not only on the reference year – here 2015 – but on many other factors. Nevertheless, the difference in emissions between a country's low- and high-ambition NDC is indicative of its mitigation possibilities and how much its ambition in domestic climate policy has to increase. For the sake of our argument, here, we assume that with infinite external funding, any country could achieve zero emissions. It is this (normalized) difference between high- and low-ambition NDCs that constitutes, therefore, our measure of climate policy ambition (CPA henceforth): $CPA = \frac{LOW\ ambition\ 2030\ emissions - HIGH\ ambition\ 2030\ emissions}{LOW\ ambition\ 2030\ emissions}$, where CPA is a continuous variable bounded between 0 and 1. Following our previous example, CPA index for Congo is 0.58 and 0.22 for India.

3.2 Between-country inequality and climate policy ambition

Figure 3 plots the correlation between GDP per capita (2015) and the change (%) recorded in ambition in domestic climate policy when external support is received, this is our climate policy ambition index (CPA). According to Figure 3, the lower the country's income, the greater is its ambition for change. In contrast, higher income countries, consistent with Figure 1, tend to present just one NDC, i.e. the difference between their NDCs is equal to zero. In this regard, between-country inequality may drive country's climate policy ambition.

Figure 3. Ambition change if external support (CPA index) to GDP per capita.



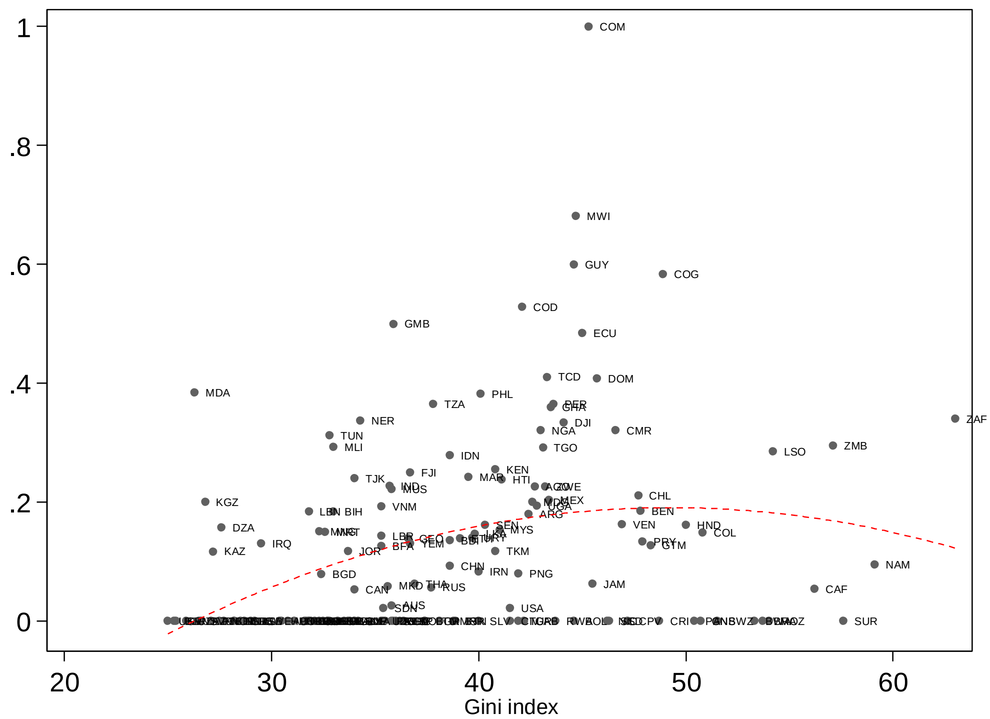
Source: Own elaboration

A relevant question here is whether countries with just one NDC are exhibiting their lowest level of ambition or, on the contrary, their highest. If the former is the case, then, countries are unwilling to achieve further mitigation targets – not even with external support – so their climate policy ambition is at its lowest. On the other hand, if the sole NDC is closest to a country's highest ambition target (perhaps, because it is a rich country), a zero difference in this instance is indicative –contrary to what we might have believed– of the highest ambition. For the sake of our argument, we assume countries with only one NDC, and hence with CPA index equal to zero, are performing their lowest ambition level. This we consider to be more sensible as a country NDC target is, at the end of the day, a compromise among different agents subject to their own budget constraints.

3.3 Within-country inequality and climate policy ambition

While the relationship between cross-country income inequality and climate policy ambition appears to be rather linear – lower income leads to higher ambition levels if external funding is received – the role played by within-country inequality is less straightforward to address. Figure 4 plots the correlation between the change in climate policy ambition (CPA index) and the Gini index, showing a non-linear relationship; low-inequality countries show low CPA, and so do high inequality countries.

Figure 4. Ambition change if external support (CPA index) to Gini Index.



If we recap Simon Kuznets seminal work (Kuznets 1955)[4] low levels of inequality are associated with either low income countries or high-income countries. Kuznets hypothesis is that as an economy grows, market forces tend first to increase inequality and then to decrease it. This being the case, to disentangle the role inequality plays in determining climate policy targets, it results paramount to take into account the associated income level. An equal society where most people is (equally) poor may deal with climate policy differently that a society in which most people is better-off.

3.4 Econometric analysis

In this paper, we estimate two basic econometric models, both using a cross-sectional sample for 2015, the year in which the Paris Agreement was signed. Our interest lies in examining statistical associations between within-country inequality and a country's climate policy ambition as measured by means of its submitted NDC (the country's projected emissions for 2030). In this regard, given the nature of our dependent variable, a panel data model would not be appropriate; however, this prevents us from eliminating unobserved heterogeneity between countries (Baltagi 2005) and, hence, omitted variable bias is a risk. As such, the econometric specifications presented here do not claim to describe any relationship of causality, rather they capture a simple statistical association in a between-country framework which, in all circumstances, allows us to discuss the relationship between a country's climate policy and its inequality.

The first model is estimated by means of an ordinary least squares (OLS) regression and its econometric representation resembles a typical environmental Kuznets curve (EKC). The second model, which is the paper's main contribution, estimates the same specification, only that here the dependent variable is climate policy ambition (henceforth CPA) as measured by the relative difference between low- and high-ambition NDCs. Since this is bounded between 0 and 1, we use a probit model. The first of these two models allows us to revisit a cross-country EKC estimation (Dasgupta 2001; Grossman and Krueger 1991) with the inclusion of inequality indices (Ravallion, Heil, and Jalan 2000; Torras and Boyce 1998). In the second model, in contrast, we make inferences as to how this inequality relates to a country's CPA.

EKC models show the relationship between economic development and environmental impact, here measured as GHG emissions per capita[5]. The main hypothesis tested in the EKC literature is whether this relationship follows an inverted-U shape: that is, as income rises, emissions increase up to a point at which they start to decline. This relationship was first observed by Grossman and Krueger (1993) who noted the resemblance with the seminal inverted U-shaped relationships between income inequality and development as described by Simon Kuznets (1955). The EKC is usually estimated using linear polynomial

[4] In his seminal paper, Kuznets shows that as countries develop from agriculture-based economy to industrial and service-based economy, inequality first increases, then peaks and finally decreases. This is an inverted U-shape relationship between income level and income inequality, a.k.a. Kuznets Curve. The curve is driven by technological progress, sectorial relocation and globalization. In early stages of development less people benefit from physical capital investment, and people start moving from agriculture to industry. In mature economies, expanded education, lower capital return, lower inter-sectorial productivity differences, and welfare state development push inequality down again. Recent research argue that the recent rise of inequality in rich economies can be explained by Kuznets waves hypothesis (Milanovic 2016). Figure A1 in the Appendix shows the Kuznets curve, in which a quadratic function resembles the Kuznets Curve in a cross country sample in 2015.

[5] See Dinda (2004) for a complete survey of the EKC hypothesis.

models including quadratic terms of income as explanatory variables[6]. If the coefficient associated with income is positive and significant while the quadratic term is negative and significant, the EKC hypothesis is not rejected and an inverted U-shape is found.

The consensus in the literature is that three main forces drive this inverted U-shape: First, the scale effect by which economic growth has a negative environmental impact due to increased production and consumption. Second, the composition effect captures the change in environmental damage attributable to the compositional change in production of an economy as it grows richer – from an agriculture-based economy to an industrial manufacturing economy to a services-based economy. Finally, an induced technique effect occurs as richer countries become more aware of environmental crises and demand greater regulation, inducing cleaner technologies in their leading industries. Based on these considerations, we estimate equation (1) while adding an inequality index and its interaction with income among the explanatory variables.

$$\ln(e_i) = \alpha + \beta_1 \ln(Y_i) + \beta_2 I_{it} + \beta_3 \ln(Y_i)\, I_{it} + \beta_4 AGRI_i + \beta_4 IND_i + \beta_4 COAL_i + \beta_4 TRA_i + \beta_4 URB_i + \varepsilon_i \qquad (1)$$

The dependent variable e_i is the GHG emissions per capita of country i in 2015 and Y_i is GDP per capita (PPP, in thousands of constant international dollars). This variable captures the scale effect. I_i is an inequality index and, since income and inequality are expected to interact non-linearly (Kuznets 1955), an interaction is included[7]: inequality (income) effect on emissions is, therefore, expected to be different at different income (inequality) levels. For instance, the predicted change in emissions associated to inequality will be equal to $\beta_2 + \beta_3(Y)$. $AGRI_i$ and IND_i denote the respective shares of agriculture and industry in the GDP and account for the composition effect. Note that this specification allows us to check the hypothesis forwarded by Gassebner, Gaston and Lamla (2008) to the effect that the more important the industrial sector, the greater is the political pressure against environmentally friendly policies and the less the environmental damage mitigation. Furthermore, $COAL_i$ is the share of electricity produced by coal and it approximates the induced technique effect. TRA_i is a country's trade openness: the more export (import) dependence, the more (less) the emissions, insofar as we are measuring production-based emissions (Peters and Hertwich 2008; Steen-Olsen et al 2016). Finally, URB_i is the urban population share.

$$\ln(CPA_i) = \alpha + \beta_1 \ln(Y_i) + \beta_2 I_{it} + \beta_3 \ln(Y_i)\, I_{it} + \beta_4 AGRI_i + \beta_4 IND_i + \beta_4 COAL_i + \beta_4 TRA_i + \beta_4 URB_i + \varepsilon_i \qquad \mathbf{(2)}$$

The second model, equation (2), shares the same specification in terms of explanatory variables. Its dependent variable, however, is CPA and the estimation method, as described, is a logistic function, insofar as the dependent variable is bounded between 0

[6] See Aislanidis (2009) for a critical review of the econometric techniques used to observe the EKC.
[7] Because of this interaction, and the inclusion of EKC's main driving forces (which are supposed to underpin the statistical significance of quadratic income), we do not include quadratic forms of income in the specification. These estimations with quadratic forms and main drivers, however, are provided in the appendixes for completeness.

and 1. Table 1 shows the main descriptive statistics of the variables used in the two econometric models.

TABLE 1. Descriptive statistics

Variable	n	Mean	S.D.	Min	0.25	Mdn	0.75	Max
D(=1 if 2 NDCs)	195	0.47	0.5	0	0	0	1	1
Income group (WB categories)	195	2.82	1.04	1	2	3	4	4
GHG per capita 2015, Gg CO2eq	192	7.07	9.15	0.64	2.12	4.31	8.37	77.95
Low Ambition NDC. GHG per capita 2030	165	7.63	11.09	0	2.5	5	8.52	105
High Ambition NDC. GHG per capita 2030	165	6.93	10.2	0	1.95	4.48	7.75	91
GDP per capita 2015 (PPP, 1000 international $)	183	17.87	19.13	0.7	3.72	11.33	25.31	115.9
Gini index	161	38.5	7.87	25	32.7	37.4	43.3	63
Palma ratio	161	2.97	1.37	1.43	2.08	2.6	3.37	10.52
Income share top 10% (%)	161	30.15	5.99	20.9	25.4	29.6	33.1	50.5
Income share top 20% (%)	161	45.55	6.48	35	40.7	44.7	49	68.2
Income share bottom 10% (%)	160	2.56	0.88	0.5	1.9	2.6	3.15	4.8
Income share bottom 20% (%)	161	6.52	1.89	1	5.1	6.7	7.9	10.8
Coal electricity production (% of total)	138	16.25	24.04	0	0	0.94	29.1	96.36
Trade openess (% of GDP)	177	88.56	50.95	19.1	56.75	77.2	107.4	416.4
Urban Population share 2015 (%)	192	57.78	23.27	12.08	39.33	57.58	77.19	100
Agriculture, Forestry and fishing Value Added (% GDP)	182	11.07	11.01	0.03	2.6	7.16	16.71	58.65
Industry (including construction) Value Added (% GDP)	184	25.21	11.16	2.07	17.69	24.27	30.3	61.36

Given our interest in inequality, we use a set of different inequality indices. This not only ensures our findings are more robust, it also allows us to analyze different perspectives of inequality. The Gini index is the most widely used inequality index, given its simplicity and its connection with the Lorenz curve. Nonetheless, its drawbacks are also well known, most notably the fact that it is highly sensitive to transfers in the distributional mean when conducting comparisons (Palma 2011). The Palma ratio was developed to address this weakness and, hence, gives all the weight to the extremes. Yet, the index shares a high correlation with the Gini index (Cobham et al. 2015). The Palma ratio shows the ratio between the income share obtained by the top 10% of recipients and the income share received by the bottom 40%. It is based on the observation of an empirical regularity according to which middle-income groups (i.e. deciles 4 to 9) systematically receive 50% of the income share. This being the case, inequality depends on how the top and bottom deciles share the remaining 50% of the income pie not captured by the middle classes. The index is intuitive and has become very popular among academics and policy makers, alike[8]. Finally, the top income shares provide further details as to the distribution of wealth in this bracket and, subsequently, serves as a measure of the elites' power (Acemoglu and Robinson 2002).

4. Results

[8] In 2013, ninety economists and development experts, including Nobel prize winning economist Joseph Stiglitz, sent a letter to the UN Economic Development Panel to put inequality and poverty eradication among its top priorities in forthcoming meetings and strongly suggested using the Palma ratio. https://www.post2015hlp.org/wp-content/uploads/docs/Dr-Homi-Kharas.pdf

4.1 Cross-country EKC hypothesis in 2015

Table 2 shows our estimate of the between-country model (equation 1) for 2015 historical emissions. Here, as expected, the level of income is positively associated with the level of GHG emissions (scale effect). Models (1) and (2) perform the EKC with the Gini index with and without quadratic income, respectively. Models (3) and (4) repeat these specifications with the addition of the remaining drivers. Only income and the share of coal in electricity production are significant in explaining between-country differences. Specifically, income elasticity ranges from 0.6 to 0.8 (that is, an increase of 1% in income is associated with an increase of 0.6-0.8% in per capita GHG emissions). Coal use in electricity production has a low elasticity, but the result is highly significant. No EKC inverted U-shape is found in this cross-country sample for 2015 and, as the adjusted R2 shows, a greater part of the variance in GHG emissions is captured with the linear rather than with the non-linear model. The Gini index coefficient presents a positive sign but, as the rest of the drivers, is non-significant.

TABLE 2

VARIABLES	(1) lnpc_ghg2015	(2) lnpc_ghg2015	(3) lnpc_ghg2015	(4) lnpc_ghg2015
ln(Y)	0.823***	0.838***	0.667***	0.657*
	(0.199)	(0.250)	(0.241)	(0.365)
ln(Y)^2		-0.002		0.001
		(0.027)		(0.038)
Gini	0.009	0.010	0.000	0.000
	(0.014)	(0.013)	(0.016)	(0.017)
ln(Y) x I_gini	-0.004	-0.005	-0.001	-0.001
	(0.005)	(0.005)	(0.006)	(0.006)
TRA			0.000	0.000
			(0.001)	(0.001)
COAL			0.006***	0.006***
			(0.002)	(0.002)
AGRI			0.011	0.011
			(0.012)	(0.013)
IND			0.008	0.008
			(0.006)	(0.006)
URB			0.004	0.004
			(0.004)	(0.004)
Constant	-0.427	-0.446	-0.655	-0.640
	(0.525)	(0.526)	(0.755)	(0.928)
Observations	158	158	118	118
R-squared	0.756	0.756	0.732	0.732
Adj. R-Squared	0.751	0.749	0.712	0.709
LL	-88.54	-88.53	-61.86	-61.86
F	181.1	137.7	46.26	42.08

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Given that income (GDP per capita) is found to be such a determinant factor, we split the sample between low-income (including, in terms of the World Bank classification, low income and middle-low income) and high-income countries (upper-middle income and high income). We use the linear model and include different inequality indices. Table 3 shows that GDP p.c. only remains important in explaining cross-country differences in the case of low-income countries. Although the two groups present different signs, the inequality indices are non-significant. Interestingly, coal remains an important driver of emissions in high-income countries but not in low-income countries, for whom trade openness is now a significant driver of emissions. Likewise, the industrial share of GDP becomes significant, with a different sign in the two groups. Thus, while in low-income countries the relevance of the industrial sector is negatively (and weakly) related to emissions, in high-income countries the opposite is the case so that the more important the industrial sector, the higher the level of emissions.

TABLE 3

	Low Income countries				High Income countries			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	lnpc_ghg	lnpc_ghg	lnpc_ghg	lnpc_ghg2	lnpc_ghg2	lnpc_ghg2	lnpc_ghg2	lnpc_ghg
VARIABLES	2015	2015	2015	015	015	015	015	2015
ln(Y)	1.390**	1.924**	1.475**	0.913**	0.764	0.605	0.559	0.813***
	(0.531)	(0.916)	(0.713)	(0.341)	(0.515)	(0.682)	(0.444)	(0.246)
highest10	0.022				0.006			
	(0.023)				(0.050)			
ln(Y) x I_highest10	-0.030*				-0.002			
	(0.017)				(0.019)			
I_highest20		0.030				-0.007		
		(0.030)				(0.044)		
ln(Y) x I_highest20		-0.032				0.002		
		(0.020)				(0.016)		
Gini			0.027				-0.012	
			(0.027)				(0.034)	
ln(Y) x I_gini			-0.026				0.004	
			(0.018)				(0.012)	
Palma				0.154				0.114
				(0.152)				(0.253)
ln(Y) x I_palma				-0.145				-0.041
				(0.103)				(0.100)
TRA	0.004**	0.004**	0.004**	0.004**	-0.000	-0.000	-0.000	-0.000
	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
COAL	0.003	0.004	0.004	0.004	0.007***	0.007***	0.007***	0.007***
	(0.003)	(0.003)	(0.003)	(0.004)	(0.001)	(0.001)	(0.001)	(0.001)
AGRI	0.003	0.003	0.004	0.004	0.032	0.031	0.030	0.034
	(0.018)	(0.018)	(0.017)	(0.018)	(0.023)	(0.023)	(0.023)	(0.024)
IND	-0.014	-0.015*	-0.016*	-0.016*	0.014**	0.014**	0.014**	0.014**
	(0.008)	(0.008)	(0.008)	(0.008)	(0.005)	(0.005)	(0.005)	(0.005)
URB	0.004	0.005	0.005	0.005	0.001	0.001	0.001	0.001
	(0.008)	(0.008)	(0.008)	(0.008)	(0.003)	(0.003)	(0.003)	(0.003)
Constant	-0.714	-1.421	-1.141	-0.554	-1.029	-0.590	-0.429	-1.202
	(1.161)	(1.513)	(1.172)	(0.972)	(1.463)	(1.924)	(1.295)	(0.740)
Observations	43	43	43	43	75	75	75	75
R-squared	0.511	0.511	0.508	0.496	0.550	0.550	0.551	0.552
Adj. R-Squared	0.396	0.396	0.392	0.378	0.496	0.496	0.496	0.497
LL	-23.91	-23.89	-24.03	-24.55	-20.99	-20.99	-20.94	-20.87
F	7.346	7.535	7.519	6.504	15.42	15.15	15.03	15.93

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The Chow test has traditionally been used in econometrics to identify structural breaks (Chow 1960). In program evaluation it is also used to determine whether intercepts and all coefficients are the same across groups, here high-income and low-income countries. It consists in an F statistic to test the equality of estimated parameters across different groups. To so do we interacted all explanatory variables with a dummy variable identifying the two groups (Wooldridge XXX). The null hypothesis is that interacted variables are jointly equal to zero, i.e. no structural break. In all cases (models 1 to 8), the null hypothesis is rejected at 1% level (Table A2 in the Appendix), meaning that the relationship between income and GHG emissions is better captured by separating high and low-income countries.

4.2 Climate policy ambition

As described above, countries freely opted to submit either one or two NDCs, the submission of a second NDC being related to a country's commitment to make a greater effort to abate domestic emissions conditional on external support being received. In contrast, a single NDC is a country's unconditional domestic abatement to be implemented with its own resources. The former, therefore, can be considered a high-ambition abatement target and the latter a low-ambition target. Table 4 shows a probit model in which the dependent variable takes a value of 1 if a country opted to submit two NDCs, i.e. a low- and a high-ambition NDC.

TABLE 4

VARIABLES	(1) D	(2) D	(3) D	(4) D
ln(Y)	-2.795***	-3.569***	-2.705***	-1.657***
	(0.815)	(1.165)	(0.862)	(0.494)
highest10	-0.131**			
	(0.056)			
ln(Y) x I_highest10	0.065***			
	(0.024)			
I_highest20		-0.118**		
		(0.058)		
ln(Y) x I_highest20		0.061**		
		(0.024)		
Gini			-0.094*	
			(0.049)	
ln(Y) x I_gini			0.049**	
			(0.021)	
Palma				-0.545**
				(0.273)
ln(Y) x I_palma				0.273**
				(0.123)
TRA	-0.008**	-0.008**	-0.008**	-0.009**
	(0.004)	(0.004)	(0.004)	(0.004)
COAL	0.009	0.008	0.008	0.008
	(0.006)	(0.006)	(0.006)	(0.006)
AGRI	-0.027	-0.026	-0.026	-0.029
	(0.033)	(0.033)	(0.032)	(0.034)
IND	0.037**	0.038**	0.039**	0.039**
	(0.018)	(0.018)	(0.018)	(0.017)
URB	0.003	0.002	0.002	0.003
	(0.012)	(0.011)	(0.012)	(0.011)
Constant	5.705**	7.113**	5.325**	3.453**
	(2.410)	(3.142)	(2.437)	(1.735)
Observations	118	118	118	118
pseudo R-squared	0.296	0.296	0.295	0.286
LL	-57.61	-57.55	-57.61	-58.42
Wald chi2	42.58	42.58	43.37	42.54

The higher a country's income, the lower is the probability of that country submitting a conditional NDC. This makes sense in the framework of common but differentiated responsibilities in addressing climate change. Inequality indices are significant and negative in all specifications, indicating that, holding all other variables constant, greater inequality is related to a lower probability of submitting a conditional NDC. Trade openness and industrial share are the other two variables showing statistical significance.

Table 5 runs the same model specification but, in this instance, using our climate policy ambition index (CPA), which consists of the relative difference between low-ambition level and high-ambition level; 0 means the country is not willing to increase its abatement effort even with external funding, and close values to 1 means a country is willing to double its abatement effort if external support is available. Notice that the Gini index shows a lower significance compared to that of both the top income share and the Palma ratio, which could be indicative of the fact that distributional extremes are more relevant than middle incomes in this matter. A legitimate hypothesis here is that the elites might oppose environmental regulations insofar as they may benefit from higher emissions (Boyce 1994). This elite effect has also been documented by Acemoglu and Robinson (2002).

TABLE 5

VARIABLES	(1) CPA	(2) CPA	(3) CPA	(4) CPA
ln(Y)	-2.782***	-3.554***	-2.695***	-1.648***
	(0.818)	(1.171)	(0.867)	(0.496)
highest10	-0.130**			
	(0.057)			
ln(Y) x I_highest10	0.065***			
	(0.024)			
I_highest20		-0.118**		
		(0.058)		
ln(Y) x I_highest20		0.060**		
		(0.024)		
Gini			-0.093*	
			(0.049)	
ln(Y) x I_gini			0.049**	
			(0.021)	
Palma				-0.542**
				(0.274)
ln(Y) x I_palma				0.271**
				(0.123)
TRA	-0.008**	-0.008**	-0.008**	-0.009**
	(0.004)	(0.004)	(0.004)	(0.004)
COAL	0.008	0.008	0.008	0.008
	(0.006)	(0.006)	(0.006)	(0.006)
AGRI	-0.026	-0.025	-0.025	-0.029
	(0.033)	(0.033)	(0.032)	(0.034)
IND	0.037**	0.038**	0.039**	0.039**
	(0.018)	(0.018)	(0.018)	(0.017)
URB	0.003	0.002	0.002	0.003
	(0.012)	(0.012)	(0.012)	(0.011)
Constant	5.671**	7.076**	5.301**	3.426**
	(2.419)	(3.155)	(2.446)	(1.742)
Observations	116	116	116	116
pseudo R-squared	0.283	0.284	0.283	0.273
LL	-57.59	-57.54	-57.60	-58.39
Wald chi2	41.34	41.44	42.30	41.21

Beyond issues of inequality, it is worth noting that we find that the willingness to make an additional abatement effort with external support is lower when the importance of trade is higher, a finding that is consistent with existing evidence. In contrast, countries in which industrial activity is more important are more willing to make an additional effort, contrary to the hypothesis forwarded by Gassebner, Gaston and Lamla (2008).

In order to see how these correlations are built, we once again split the sample between low- and high-income countries and run the same model (Table 6). According to the Chow test[9], we cannot reject the null hypothesis of no structural break (Table A2). Therefore, we cannot reject the hypothesis that slope coefficients and intercepts are equal across models. Yet, interesting insights are provided. We find that inequality only remains as a negative driver of climate policy in the case of low-income countries. Based on this outcome, the elite effect would appear only to be present in lower-income countries, that is, a high concentration of income can be related to a low level of climate policy ambition. In high income countries, by contrast, inequality is non-significant. Indeed, according to the results in Table 6, the only factor that negatively affects climate policy ambition for these countries is trade. When we split this variable between the share of exports and imports, only exports are found to be significant and negative. If, as these results suggest, exports are a relevant factor for a rich country, a higher level of ambition may be considered to compromise its competitiveness.

TABLE 6

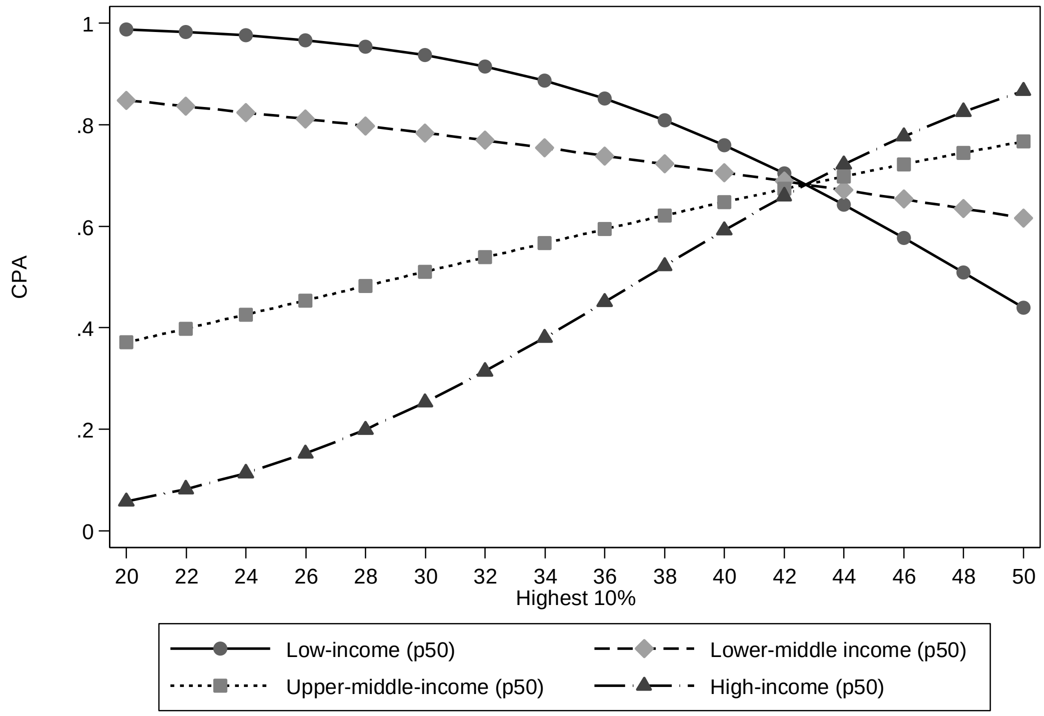
[9] The Chow test for a non-linear model is calculated by means of a Likelihood Ratio test which is Chi2 under the null hypothesis (Andrews and Fair, 1988).

	Low Income Countries				High Income Countries			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	CPA	CPA	CPA	CPA	CPA	CPA	CPA	CPA
ln(Y)	-5.238**	-7.708**	-5.310**	-3.252***	-2.813	-3.510	-2.618	-1.460
	(2.229)	(3.361)	(2.455)	(1.230)	(2.362)	(3.193)	(2.234)	(1.094)
highest10	-0.191**				-0.149			
	(0.086)				(0.218)			
ln(Y) x I_highest10	0.142**				0.068			
	(0.067)				(0.080)			
I_highest20		-0.201**				-0.130		
		(0.098)				(0.195)		
ln(Y) x I_highest20		0.148**				0.060		
		(0.068)				(0.071)		
Gini			-0.156*				-0.098	
			(0.085)				(0.159)	
ln(Y) x I_gini			0.113**				0.046	
			(0.057)				(0.057)	
Palma				-1.038**				-0.376
				(0.435)				(1.014)
ln(Y) x I_palma				0.819**				0.181
				(0.345)				(0.396)
TRA	0.004	0.004	0.004	0.004	-0.019***	-0.019***	-0.019***	-0.020***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
COAL	0.033**	0.034**	0.034**	0.034**	0.003	0.003	0.003	0.003
	(0.014)	(0.013)	(0.014)	(0.014)	(0.007)	(0.007)	(0.007)	(0.007)
AGRI	-0.021	-0.022	-0.023	-0.022	0.020	0.021	0.022	0.022
	(0.038)	(0.036)	(0.036)	(0.037)	(0.101)	(0.100)	(0.100)	(0.100)
IND	-0.002	-0.001	0.002	-0.004	0.031	0.032	0.033	0.032
	(0.032)	(0.031)	(0.031)	(0.032)	(0.026)	(0.026)	(0.026)	(0.025)
URB	0.005	0.005	0.003	0.003	-0.017	-0.017	-0.017	-0.014
	(0.018)	(0.018)	(0.017)	(0.017)	(0.019)	(0.019)	(0.019)	(0.020)
Constant	7.449**	10.902**	7.767*	4.768*	8.523	9.915	7.854	5.319
	(3.603)	(5.271)	(4.177)	(2.449)	(7.533)	(9.789)	(7.243)	(4.129)
Observations	43	43	43	43	73	73	73	73
pseudo R-squared	0.211	0.219	0.211	0.230	0.378	0.380	0.381	0.369
LL	-20.78	-20.59	-20.79	-20.29	-30.73	-30.63	-30.60	-31.18
Wald chi2	14.23	14.65	13.74	15.76	29.43	29.81	30.36	30.91

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Regarding the effect of inequality on climate policy ambition, the main finding here is that its marginal effect depends upon the level of country's GDP per capita (captured by the interaction effect); the higher the GDP per capita, the less negative is the inequality for climate policy (i.e. lower the elite effect). Figure 5 plots the predicted marginal effects of the (preferred) aggregate model (in Table 5) by median income in World Bank income categories. Poorest countries show a negative curve pointing to some sort of elite effect. Rich countries higher income, however, more than compensates the inequality negative coefficient, showing a positive relationship between inequality and climate policy ambition and hence potentially reflecting climate policy as a superior good.

FIGURE 5. Predictive margins of Inequality by World Bank income categories (median income)



Notes: Predictive margins model (1) in Table 5

5. Conclusion

To date, the literature addressing the relationship between income inequality and environmental deterioration has provided diverse theoretical insights and inconclusive evidence. While there is a growing body of evidence on the relationship between social inequality and emissions, the literature on the potential effects of income inequality is much scarcer. In this study we have undertaken an empirical analysis of the effect of income inequality on climate policies as defined in the Paris Agreement.

To study the effects of between-country, as well as within-country, income inequality on climate policy ambition we have used several inequality indexes in conjunction with data obtained from the Paris Agreement on the INDCs – both without and with external support – to fight climate change.

Our results suggest that the lower the country's income, as measured by GDP per capita, the greater is its level of ambition when external support is made available. Additionally, we find that within-country inequality is associated with lower mitigation ambition. This relationship holds for low- and middle-low-income countries, but we find no significant relationship between inequality and mitigation ambition for high-income countries.

Our analysis does not allow us to establish any causal mechanisms via which income inequality translates into climate policy ambition, but various explanations might be offered: in low-income countries, inequality might concentrate greater political power in the hands of the elite, who benefit from polluting economic activities; or, as environmentally friendly policies have the characteristics of a superior good, more unequal societies might experience less political pressure from middle classes to engage in ambitious environmental policies. We believe that a promising avenue for future research is to analyze whether the quality of democracy might be influencing the relationship between inequality and climate policy ambition.

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Appendix

Table A1. Data sources and variable definition

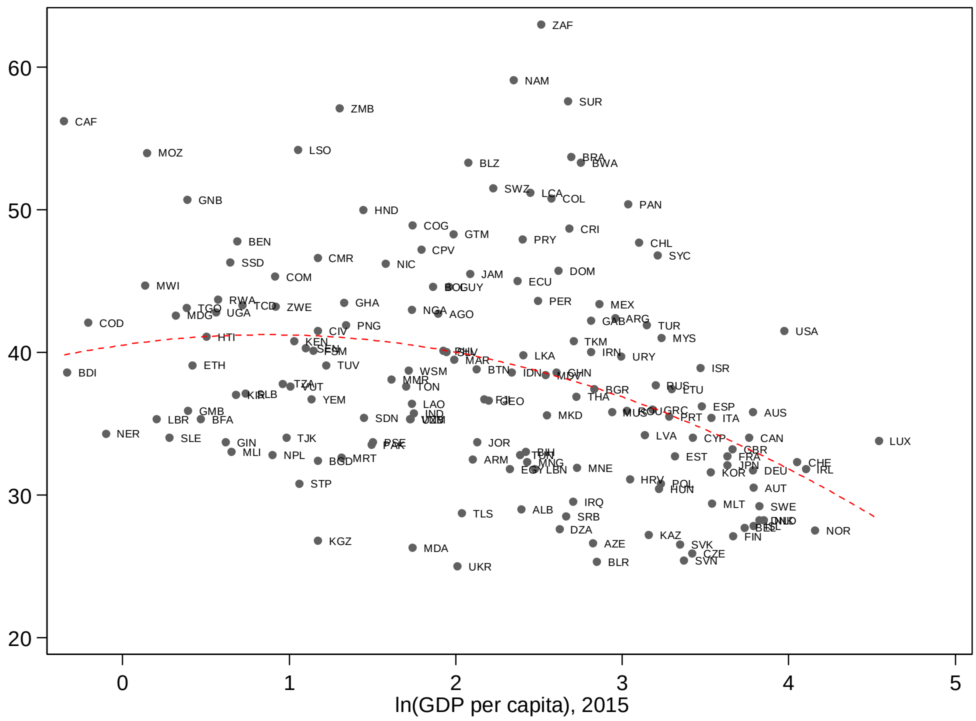
Variable	Definition	Data source
D	D(=1 if 2 NDCs)	Meinshausen and Alexander (2017)
Wbcat	Income group (WB categories)	WB data (2019)
E	GHG per capita 2015, Gg CO2eq	PIK. Gütschow et al. (2019)
LowNDC	Low Ambition NDC. GHG per capita 2030	Meinshausen and Alexander (2017)
HighNDC	High Ambition NDC. GHG per capita 2030	Meinshausen and Alexander (2017)
Dif	Ambition change (LowNDC- HighNDC)/lowNDC	Meinshausen and Alexander (2017)
Y	GDP per capita 2015 (PPP, 1000 international $)	WB data (2019)
I_gini	Gini index	WB data (2019)
I_palma	Palma ratio	WB data (2019)
I_highest10	Income share top 10% (%)	WB data (2019)
I_highest20	Income share top 20% (%)	WB data (2019)
I_lowest10	Income share bottom 10% (%)	WB data (2019)
I_lowest20	Income share bottom 20% (%)	WB data (2019)
COAL	Coal electricity production (% of total)	WB data (2019)
TRA	Trade openness (% of GDP)	WB data (2019)
URB	Urban Population share 2015 (%)	WB data (2019)
AGRI	Agriculture, Forestry and fishing Value Added (% GDP)	WB data (2019)
IND	Industry (including construction) Value Added (% GDP)	WB data (2019)

Table A2. Structural change test

	(1)	(2)	(3)	(4)
Model Dep. Var (Ineq. Index)	lnpc_ghg2015 (highest10%)	lnpc_ghg2015 (highest20%)	lnpc_ghg2015 (Gini Index)	lnpc_ghg2015 (Palma Ratio)
Chow Test: F(9,100) [p>F]	4.12 [0.0002]	3.93 [0.0003]	3.75 [0.0004]	3.59 [0.0007]
Model Dep. Var	CPA	CPA	CPA	CPA

(Ineq. Index)	(highest10%)	(highest20%)	(Gini Index)	(Palma Ratio)
Chow Test:				
LR [p>χ²]	12.16 [0.2045]	13.26[0.1513]	12.18 [0.2036]	12.83 [0.1706]
Wald test [p>χ²]	10.40 [0.3191]	10.99[0.2765]	10.21 [0.3339]	11.09 [0.2698]

Figure A1. Kuznets Curve. Cross-country 2015



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