Non-homothetic green preferences. A new approach to the impact of economic growth on the environment.

M. Gilli (University of Ferrara), F. Vona (OFCE-SciencePo), F. Nicolli (European University Institute)

Very preliminary draft – not to be cited

This work has the ambitious aim of building a new Environmental Kuznets Curve (EKC), which accounts for non-homotheticity in green preferences and sharp nonlinearities in the impact of economic growth on the environment. Theoretically, our research is motivated by the fact that, if environmental quality is a good with low priority in the hierarchical scale, both the first- and the second-moments of the within-country distribution of income matters in shaping pollution impacts of growth. Particularly, for a given level of income per capita, a richer median voter will be more willing to approve more stringent environmental policies and thus a lower inequality is beneficial for the environment. With non-homothetic preferences, the beneficial environmental effect of reducing inequality emerges only for countries that are sufficiently rich. We test this hypothesis augmenting standard reduced form equation for EKC including the interaction between income per capita and the Gini coefficient. Our results for CO2, SO2 and NOx emissions corroborate our main hypothesis: reducing inequality is beneficial for the environment only for rich countries. Finally, we show that results are stronger for democracies.

Introduction

In 2016 the United Nations lunched an ambitious and transformative agenda generally known as "Sustainable Development Goals". The three main pillars of this new set of targets, which replace the Millennium Development Goals released in year 2000, are social, economic and environmental sustainability. Nevertheless, the interplay among these factor is non obvious and need a special attention. Since the seminal contribution of Revallion (2000), for instance, the literature has highlighted as there exist a trade-off between reducing inequality and reducing carbon emission. This result can make the achievements of the Sustainable Development Goals particularly hard, if working towards one the target (e.g. reducing inequality), really hamper the effort placed in reaching the other objectives (e.g. environmental sustainability). Nevertheless, a consolidated theoretical and empirical framework on the interplay of these factors is still lacking in literature, as recently shown in the review by Berthe and Elie (2015).

Given these premises, the aim of this paper is to instigates if and how inequality impact on air polluting emission (CO2, SO2 and NOX), and whether this relationship depends on per capita income levels. This contribution is motivated by the fact that, if environmental quality is a good with low priority in the hierarchical scale, both the first- and the second-moments of the within-country distribution of income matters in shaping pollution impacts of growth. Particularly, for a given level of income per capita, a richer median voter will be more willing to approve more stringent environmental policies and thus a lower inequality is beneficial for the environment. With non-homothetic preferences, the beneficial environmental effect of reducing inequality emerges only for countries that are sufficiently rich.

To our knowledge, empirical evidence in this field is still rather scarce and generally limited to CO2 only (a recent paper closely related to ours is Grunewald et al, 2017); and as suggested in Berthe and Elie (2015) much more research is needed in this field. We enrich this literature in several dimension. Firstly, we build and exploit a rich dataset for each pollutant, as outlined in the methodological section. Secondly, we do not focus on CO2 only, but we also study other relevant pollutants like SO2 and NOX. As we will show in the empirical analysis, the trend for these pollutants are fairly heterogeneous and different approaches tell different stories. Finally, we introduce a new mechanism, studying how democracy can influence the effect that inequality plays on emission, at different level of income.

Our main findings suggest that, in the case of NOx and SO2, for the first seven percentiles of per capita income distribution, higher inequality is associated with increasing environmental quality, while the opposite hold for the two highest quintile of incomes. In the case of CO2, we do not find any evidence of an effect of inequality on emission. Finally, our results are stronger in Democratic society.

The remaining part of the paper is organised as follow: the background section studies the theoretical literature upon which our empirical strategy is based; the research framework section present the dataset and the specification of the model; the results section present some very preliminary evidence and the last section concludes.

Background

In the last two decades, the environment-income relationship has been studied under the consolidated framework generally known as Environmental Kuznets Curve (EKC). The main intuition behind this approach is that the relationship between environmental degradation and economic growth has an inverted U relationship. This means that in the first stage of economic development, income growth is generally correlated with an increasing trend in degradation, while after a certain threshold (generally called turning point), some sort of delinking between the two variables start to occur. In some instances, also an N-shape curve might appear, which means that after a certain threshold, relinking is possible. Economic literature has found several explanations for this relationship, among which, the most consolidated ones are the following: a threshold effect in abatement strategies; income-driven demand of environmental protection (and policies) and transition towards a service based economy; increasing return to scale of abatement technologies.

Starting from this context, the EKC literature, as recently surveyed in Carson (2010), has highlighted at least three mechanisms behind the environment-income relationship. These are generally known as scale, composition and technological effect. The first of these effects, generally known as scale or volume effect, is fairly straightforward. It is generally assumed, in fact, that as the scale (or size) of one economy becomes bigger, the higher become the anthropogenic impact it has on the environment. The assumption behind this effect is, clearly, that the elasticity of the relationship between income and degradation remains constant as income rises. There are, however, at least two reasons why this assumption can be considered too strict. Firstly, as income rises, the composition of the economy may change, and this can have contrasting effect on the environment-income nexus. A change in composition generally means a shift toward a service- based economy, which is often assumed to be good for the environment given the lower emission intensity of the manufacturing sector per unit of output. Nevertheless, under certain conditions this transition can also harm the environment. First of all, many service sectors rely heavily on industrial and polluting inputs and second, the well-known "cost disease" introduced in Baumol (1967), suggest that, moving from a static to a dynamic perspective, service sectors have less stimuli to innovate, decreasing (in the medium run) all the improvements in environmental performances due to environmental innovation. Secondly, also technological change can influence, to a great extent, the relationship between income and the environment. The obvious intuition here is that green technological change, increasing environmental productivity (EP), can decrease the elasticity between economic growth and the environment, lowering down the EKC. The relevance of green technological change inside this debate has been stressed by several contributions in literature. Vollebergh and Kemfert (2005), for instance, highlight the need of more radical innovation, which is, in their view, a fundamental step in the process of decarbonisation of the economy. Consequently, we expect income per capita and polluting emission to show an an inverted-U or N-shaped relationship.

A second relevant strand of literature relates more closely to the relationship between inequality and emissions. Among theoretical studies, there is still a lack of consensus on the direction of this nexus. Early studies by Boyce (1994), Torras and Boyce (1998) and Borghesi (2006) predict a negative association between income inequality and emission. The main argument in favour of this hypothesis is that, being environmental quality a normal good, the richer is the median segment of the population, the higher is the demand for environmental protection. On the contrary, in a more unequal society, those who benefit from pollution usually holds more power than these who bear the cost. A similar argument has been put forward by Magnani (2000). A completely different result has been found by McAusland (2003), according to which the effect of inequality on the environment cannot be predicted a priori and depends on the level of ownership concentration and openness to trade in countries. Gassebener et al. (2008), show as in high income countries, rising income inequality imply outsourcing of industrial production as well as skill-biased technical change which is generally associated with an accelerated industrial decline. This process has important implication on the political process, as it might reduce the power of industrial producers and workers of lobbying against environmental policies, improving overall of environmental quality. According to the interpretation of this work given in Grunewald et al, (2017), the opposite effect can be found for poor countries.

The empirical studies in this field present mixed results. Ravallion et al. (2000) and Heernik et al. (2001), found a trade-off between reducing carbon emissions and reducing income inequality. Borghesi (2006), found that inequality has no effect on emissions. More recently, the work by Hubler (2017) confirms the trade-off between inequality and emissions, while Grunewald et al, (2017) finds that for low income countries, higher income inequality is associated with lower CO_2 emissions, while in high-income countries, higher income inequality increases per capita emissions. All these studies focussed on CO_2 emission only.

In this analysis, we follow the main intuition that inequality influence the wealth and consequently the preferences of the median voter. The effect, however, vary with income level. In poor society, inequality implies a concentration of wealth amongst the richest tail of population, which are more likely to demand for environmental protection (with respect to a more egalitarian society); in rich countries, inequality means a poorer median voter (Magnani, 2000), and consequently a lower demand for environmental protection. Summarising, we expect the beneficial environmental effect of reducing inequality to emerge only for countries that are sufficiently rich. Since the work by Boyce (1998), the main assumption of these studies is that more democratic society produce better environmental results, as the median voter preference toward the environment are more likely to be translated in environmental policies through the political process. On the contrary, an autocrat can be more incline to listen to the voice of brown lobbies, which often represent a smaller and richer share of the population. A recent contribution by You et al. (2015), for instance show as democracy appear to reduce CO_2 emission, but this effect is stronger in more polluting countries. As a consequence, we expect our results to be stronger in democracies.

Research framework

Data

We collected data on emissions, inequality, population and gross domestic products from different sources.

The dependent variable is always the level of emissions by country. Specifically we used information on three pollutant, carbon dioxide (CO_2) nitrous oxides (NO_x) and sulphur dioxide (SO_2) and built three different model for each pollutant.

Data on CO_2 emissions are gathered from the Carbon Dioxide Information Analysis Centre[1] (CDIAC) a data archive containing information on global, regional and national fossil fuel CO_2 emissions. Data are available from 1870 until 2013, but we exploited the most complete information, available from the 1960s for 173 countries.

SO_2 emissions data are collected from the NASA SEDAC (Socioeconomic Data and Application Center) database, which has available national and regional datasets from 1850 to 2005. The database includes emissions by country and by source category (coal, petroleum, biomass combustion, smelting, fuel processing, and other processes). Also in this case we exploited the most complete information: from the 1970s to 2005 for 117 countries.

[1] From September 2017 the CDIAC archive has moved to the U.S. Department of Energy's (DOE) Environmental System Science Data Infrastructure for a Virtual Ecosystem (ESS-DIVE) archive

The last pollutant we considered is NOx for which data are available from the World Bank World Development Indicators[2] (WDI). In this case data were available since the 1970s to 2016, for 204 countries.

Data on population and gross domestic products were gathered from the Penn World Tables, one of the largest source for real national accounts data. The national accounts for each country, initially in their own currencies, are adjusted using detailed price data to obtain real national accounts in a common currency (U.S. dollars) across countries. Both population and gross domestic products are expressed in thousands of people and thousands of dollars respectively and are available for 173 countries between 1960-2013.

We used these information to create per capita emissions indicators and per capita gross domestic products indicator. According to Galeotti et al (2011) and Casey and Galor (2016) we also included demographic change in our model.

The choice of a correct measure of income inequality has been the most difficult. In fact, several databases on Gini index are available. As outlined in Atkinson and Brandolini (2001; 2009) and Jenkins (2009) there are issues related to the use of macro level datasets on income inequality, arising from the inclusion of several micro-observation to form a unique piece of macro information, and the subsequent of the macro-observation to create a unique piece of information per country. Correctly addressing these issues allows achieving a good level of comparability among inequality indices across countries and years. The first point in question is the choice of the definition of income on which the index is computed: typically, the choice is between an income-based definition of inequality (and later between gross or net income) and an expenditure-based definition. These are clearly different, since consumption, based inequality tends to vary less through time. Finally, note that also definitions of income and expenditure can be different across databases. The second argument relates to the need of clarify which is the unit of reference, i.e., if the inequality is computed for a household or a nuclear family or an individual or a tax unit. In this regard, an additional point needs to be considered, namely the use of an equivalence scale to adjust for the size and composition of the reference unit. Moreover, in some source database it is possible to find that, beside the equivalization, observations are weighted according to the size and composition of the reference unit. Finally, inequality observations might have different reference periods, even though usually this reference is the year. When the reference time of the observation is below the year, issues related to seasonality may arise.

Based on this premises, three secondary datasets are considered before choosing the "preferred" one. The first is the *World Income Inequality Database* (WIID), developed by the United Nation University which collects information on 182 countries and is compiled since 1997. Data included in the WIID are taken from several sources, including the Organization for Economic Development and Cooperation (OECD), Eurostat, the Luxembourg Income Study (LIS) and the World Bank. Contrary to the other two databases, the WIID do not estimate a unique Gini index for each country, rather it presents several observation for the same country-year coming from different sources (where applicable) and includes a set of variables which incorporates as much source information as possible for each index. Clearly, the rationalization is that by allowing the researchers to choose observation which are determined with the same criteria (i.e., the same definition of income, the same unit of analysis, and so on…), the issues related to comparability will be mitigated.

Indeed, according to Atkinson and Brandolini (2001, p. 790): "Users should decide on the definition they wish to apply and then select the appropriate observations […]. The less prescriptive approach in the WIID dataset, forces the user to make such choices […]." Notwithstanding the

[2] The actual source of this world bank data is the European Commission, Joint Research Centre (JRC)/Netherlands Environmental Assessment Agency (PBL). Emission Database for Global Atmospheric Research (EDGAR)

reasonableness of this approach, there are a few shortcomings involved. First, there are not multiple sources for all countries, and the highest quality data tend to be more available for advanced economies that for developing ones. Second, and consequently, choosing observation of the same quality greatly reduces the number of available information. Therefore, in an analysis with a large number of countries involved, as the present one, some adjustment might still be necessary.

When dealing with several and different estimates, a common adjustment procedure is the use of dummy variables. Even though this kind of adjustment was firstly recommended in Deininger and Squire (1996), both Atkinson and Brandolini (2001; 2009) and Jenkins (2009) are sceptical about their application, because a simple dummy variable cannot fully capture quantitatively important differences in definitions of income, unit of references or equivalence scale. Solt (2016) is also is critical about the dummy variable approach, because it assumes that differences between observations are always the same, between countries and through time. In his *Standardized World Income Inequality Database* (SWIID), he obtains unique series of Gini estimates, by applying an innovative and complex procedure to 10,000 Gini observations from different sources (e.g., OECD Income Distribution Database, the Socio-Economic Database for Latin America and the Caribbean generated by CEDLAS and the World Bank, Eurostat and academic studies) which are combined together and evaluated in terms of success in predicting the inequality as in the Luxembourg income study, used here as a benchmark value for Gini. The algorithm employed maximises the information contained in each database and ensures that comparability is met and coverage is broader that in other data archives. The advantage in using this database is that the available information are greater than in the WIID and comparability is tackled in a more robust way than the use of dummy variables.

Finally, the last data archive we considered is *All the Ginis* (Milanovic, 2014) which collects Gini coefficients from surveys from 1950 to 2012. The coefficient retrieved by none sources[3] are then included in a final Gini variable. The author call this process standardization, which, in this case, follows an ad hoc procedure based on the criterion of the "choice by precedence". The author establish a hierarchy among the different sources and pick the country observation from the highest source in the hierarchy, discarding the other ones (for the same country). The final database contains 4132 observation for the standardized Gini variable. Even though this process ensures that the selected Gini observations are of high quality, the choice of the hierarchy of surveys is not objective.

Therefore, our preferred source of data on inequality is the SWIID, because of the greater coverage in terms of countries and because of a good degree of comparability among the information on Gini that are contained. Notwithstanding that, in order to prove the robustness of our results we also carried the empirical analysis using the other two databases. Even though the number of observation is quite reduced, especially in the case of WIID, the results are mainly unchanged.

Choice of the specification

Our baseline specification is reported in equation 1 below:

$$e_{it} = \alpha + \beta_1 gini_{it} + \beta_2 gdp_{popit} + \beta_3 gdp^2_{popit} + \beta_4 gdp^3_{popit} + \beta_5 \Delta pop_{it} + \beta_6 gini_{it} * gdp_{popit} \quad \text{(eq.1)}$$

Where $gini_{it}$ is the Gini coefficient from the SWIID database, for country *i* at time *t*; gdp_{popit} is the per capita domestic product of country *i* in time *t* and gdp^2_{popit} and gdp^3_{popit} are exponential

[3] Luxembourg Income Study (LIS); Socio-Economic Database for Latin America and the Caribbean (SEDLAC); Survey of Income and Living Condition (SILC); World Bank's Eastern Europe and Central Asia (ECA); World Income Distribution (WYD); POVCAL; World Institute for Development Research WIDER (WIID1); CEPAL; Individual data sets (INDIE).

transformation of the same variable. Δpop_{it} is the log of the variation of population from year *t-1* to year *t* while the last term $gini_{it} * gdp_{popit}$ is the interaction term between inequality and per capita income. Our parameter of interest are β_1 and β_6. In fact, we expect that that not only inequality is relevant with respect to environmental quality but also that there are different implications for the environment with respect to a country's level of income.

We estimate a fixed effect model and include time effect to take into account unobserved factors such as the effect of economic shocks.

In a second step of the analysis we also include a democracy variable. Information on the level of a country's democracy are retrieved from Polity IV a database that collects information on political regimes characteristics and transition from 1800 to 2013. The polity indicator ranges from -10 (full autarchy) to 10 (full democracy) while the democracy threshold is considered at 6. We then built a dummy variables which takes value one if a country has a polity value of at least 6, and interacted it with both Gini and GDP.

Before arriving to the final specification in equation 1, we needed to address some issues. A first point related to the choice of how to include the non-linearity of gross domestic product in the model, in other words, how should we specify the EKC. In fact, the literature presents contribution where the relation is specified as having either an inverted U shape or an N shape. Moreover, we noticed that the choice of taking logarithms of both sides of the equation somehow affects this choice, because it changes the way in which the non-linearity is taken into account.

Often in the literature, non-normality of both sides of the equation is addressed by taking log transformation of the variables. However, we believe this approach might lead to misspecify the relation. In fact, on the right hand side of the equation non-linearity of per capita gross domestic product is already taken into account when including the quadratic and, in our case, also the cubic term. Therefore, taking logs of the exponential variables will flatten the effect of the third grade polynomial, causing the loss of important pieces of information. After extensive testing, we do find that while the results of a log model including only the squared term are in line with the literature, the fit of the data[4] is substantially improved when we consider the right hand side of the equation in levels and include a cubic term, such as in equation 1.

The second step is to compare the usual EKC model with our inequality-augmented version of the model, which includes the Gini index and its interaction with per capita GDP. Notice that this latter term captures if reducing inequality is beneficial for the environment only for rich countries. As shown in table 1 in the next section, results of the first three columns are in line with the existing literature. However, when we consider the inequality-augmented model, part of the significance of the per capita GDP term is captured by inequality and the interaction term, which is the result we expected. For the sake of completeness, we also included inequality in equation 1, and found confirmation of our results for CO2 and SO2 emissions[5].

Preliminary results

Table 1 below presents result for our baseline specification. The first three columns show the effect of per capita income only, while the last three column present results also for inequality and its interaction with income.

[4] We compare F statistics, likelihood ratio and information criteria (AIC). All these indicator suggest that our model should be preferred.

[5] Results are available upon request

The effect of GDP is always in line with the main prediction of the EKC. Given the high heterogeneity of countries included in the analysis, an N-shape form is more suitable to represent the data, but it has to be noted here that only a few countries are on the right of the second turning point. This means, in other term, that an evidence of recoupling exists, but its role is limited (about the 5% of observation).

When it comes to the effect of Gini, the evidence is mixed across the three pollutants. For NOx, the effect of GINI is not statistically significant, but its interaction with GDP is strongly significant. This means that inequality has an effect, but only after a certain threshold of income. In other terms, a reduction of inequality has no effect on emission in poor countries, but it can contribute in reducing emission in richer ones.

The effect on SO2 is, on the contrary, much more significant. Both the coefficient of GINI and of the interaction are statistically significant, and show the expected sign. Overall, a reduction in inequality is associated with higher emission in poorer households, but this effect change of sign around the 60 percentile of income distribution (see Figure 2). Finally, in the case of CO2, there effect is non-significant. This result is in line with the controversial evidence found in literature.

In order to have a quantification of these results, we plotted in Figures 1 to 3 the total effect of GINI at different level of the income distribution. The effect is standardised. Overall, the figures show as the change in the direction of the effect of GINI always occur between the 5^{th} and the 6^{th} decile of income distribution.

Table 1. Comparison between the EKC model and the Inequality-augmented EKC model

VARIABLES	EKC Log(NOx)	EKC Log(SO2)	EKC Log(CO2)	Inequality-EKC Log(NOx)	Inequality-EKC Log(SO2)	Inequality-EKC Log(CO2)
Gini				-0.00672	-0.0403***	-0.00531
				(0.00462)	(0.00986)	(0.00491)
GDP_{pop}	0.0819***	0.123***	0.306***	0.0193	-0.0497	0.0722***
	(0.0240)	(0.0372)	(0.0255)	(0.0135)	(0.0345)	(0.0196)
GDP_{pop}^2	-0.00269***	-0.00504***	-0.00779***	-0.00110***	-0.00437***	-0.00245***
	(0.000824)	(0.00115)	(0.000954)	(0.000253)	(0.000988)	(0.000419)
GDP_{pop}^3	2.43e-05***	4.27e-05***	5.75e-05***	8.01e-06***	3.84e-05***	1.76e-05***
	(7.39e-06)	(1.17e-05)	(9.57e-06)	(1.79e-06)	(9.57e-06)	(3.35e-06)
Δpop	-0.478***	-0.0156	0.0264	-0.0100	-0.0440	-0.0186
	(0.0141)	(0.0446)	(0.0319)	(0.0200)	(0.0373)	(0.0299)
Gini* GDP_{pop}				0.000739***	0.00432***	0.000475
				(0.000234)	(0.000644)	(0.000358)
Constant	4.492***	2.369***	6.576***	6.384***	4.025***	6.910***
	(0.127)	(0.242)	(0.0729)	(0.203)	(0.454)	(0.267)
Observations	7,151	2,448	8,840	3,470	2,448	3,664
Number of countries	172	117	173	156	117	157
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes

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

Figure 1. Marginal effect of an increase in inequality for increasing level of per capita income. NOx emission.

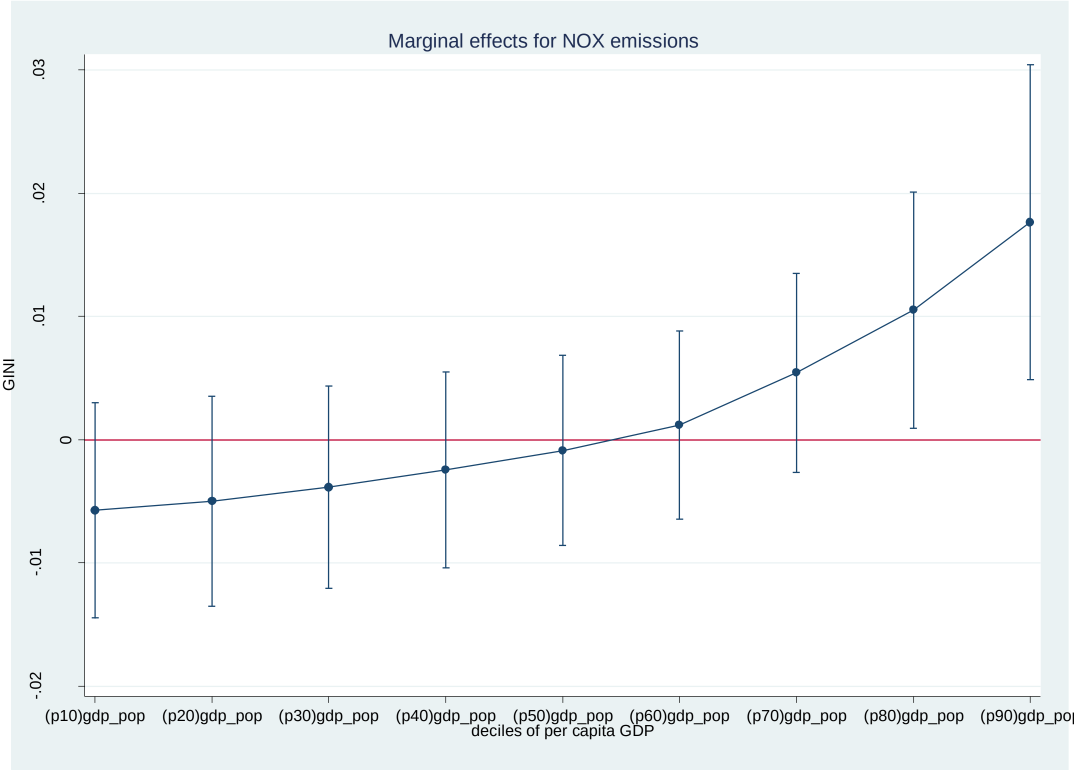

Figure 2. Marginal effect of an increase in inequality for increasing level of per capita income. SO2 emission

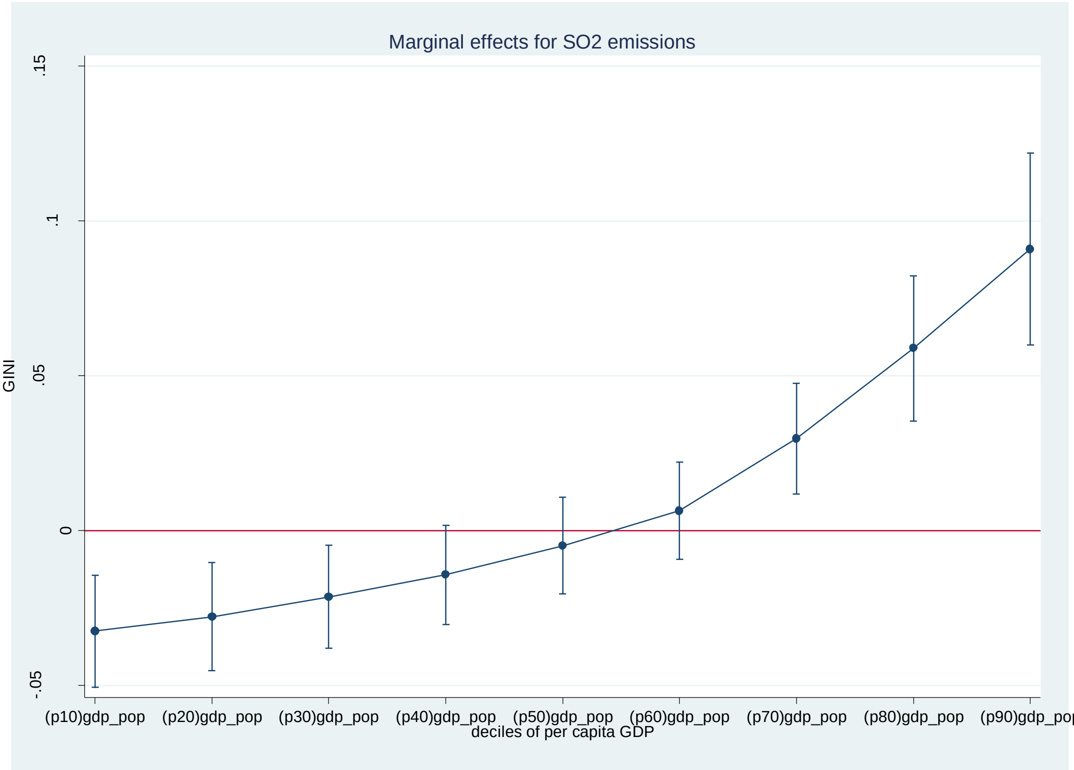

Figure 3. Marginal effect of an increase in inequality for increasing level of per capita income. CO2 emission

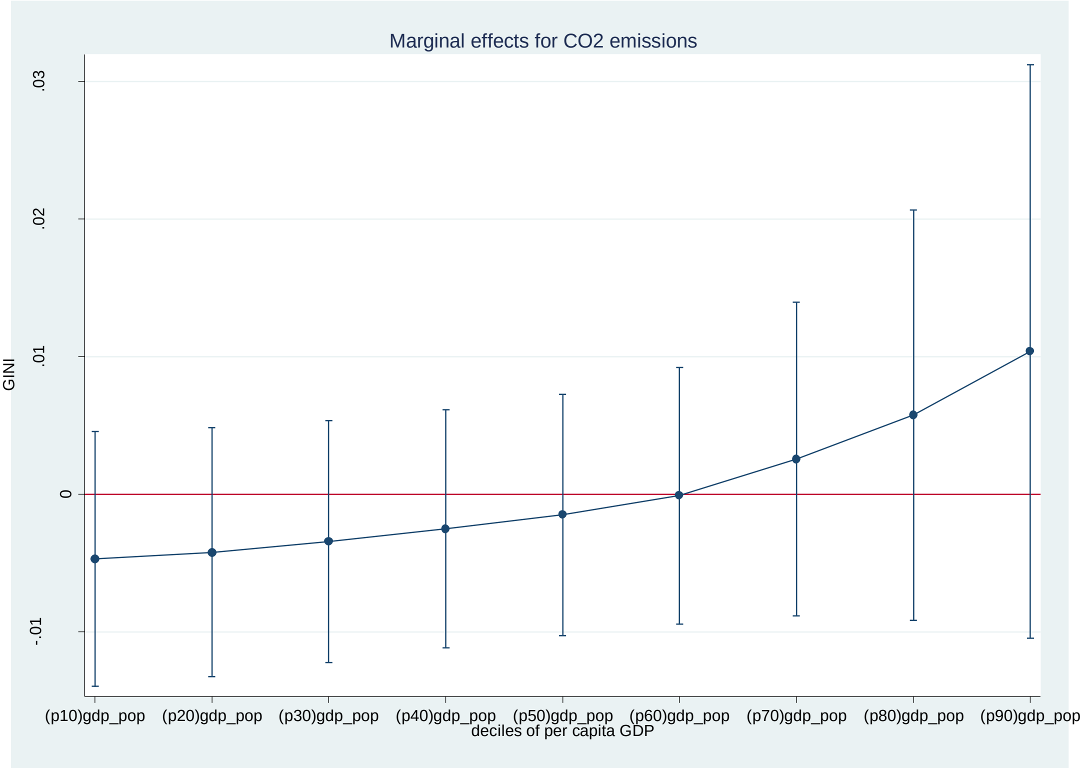

Table 3 below present result for a specification augmented to test the effect of democracy. In particular, what we did here is to introduce a triple interaction in which we test for the hypothesis that in democratic countries, the effect found above is stronger with respect to autarchic countries. Overall, regression results confirm this hypothesis. Firstly, we note as the main evidence found in the baseline analysis still holds. The N-shaped curve is confirmed for all three pollutants. In the case of NOx, the coefficient of Gini is not significant, but the interaction is statistically significant and associated with the expected positive sign. In the case of SO2, the result are in line with theoretical prediction and always strongly statistically significant. As before, no results are found for CO2.

Overall, this further step of analysis confirms our hypothesis that the effect of reducing inequality on environmental quality is stronger in democratic society.

Table 2. Fixed effect model discriminating between democratic and non-democratic countries

VARIABLES	(1) Log(NOx)	(2) Log(SO2)	(3) Log(CO2)
Gini	-0.00314	-0.0353***	-0.00324
	(0.00434)	(0.00875)	(0.00533)
Democracy=1	0.0615	0.293***	0.0180
	(0.0476)	(0.0911)	(0.0568)
GDP_{pop}	0.0350**	-0.0522	0.0850***
	(0.0167)	(0.0375)	(0.0216)
GDP_{pop}^2	-0.00108***	-0.00392***	-0.00250***
	(0.000257)	(0.000950)	(0.000417)
GDP_{pop}^3	7.91e-06***	3.50e-05***	1.80e-05***
	(1.67e-06)	(8.62e-06)	(3.29e-06)
Δpop	-0.0182	-0.0549	-0.0393
	(0.0204)	(0.0345)	(0.0303)
Democracy=0* Gini* GDP_{pop}	0.000502**	0.00490***	0.000247
	(0.000211)	(0.000706)	(0.000435)
Democracy=1* Gini* GDP_{pop}	4.00e-05	0.00360***	7.34e-05
	(0.000284)	(0.000813)	(0.000470)
Constant	6.263***	3.692***	6.786***
	(0.203)	(0.408)	(0.280)
Observations	3,320	2,393	3,501
Number of countries	141	114	142
Year fixed effects	Yes	Yes	Yes

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

Conclusion

The aim of this paper is to offer a new and more complete perspective on the relation between environmental quality and economic growth. To do so, we augment a standard EKC model with an inequality term and its interaction with per capita income. Our preliminary results presents new evidence on the inequality-environment nexus. Firstly, we show as this relationship depend on the level of income. For countries below the 6^{th} decile of income distribution, a decrease in inequality is on average associated with higher emission. After this threshold, a reduction in inequality is good for the environment. Secondly, we show as studying different pollutants has an added value. If, from the one hand, we do not find any interesting result using CO2 as main dependent variable, using SO2 and NOX a more robust evidence emerge. Finally, our preliminary analysis show as democracy can be one of the channel which can strengthen this effect.

References

Atkinson, A. B., & Brandolini, A. (2001). Promise and pitfalls in the use of" secondary" data-sets: Income inequality in OECD countries as a case study. Journal of economic literature, 39(3), 771-799.

Atkinson, A. B., & Brandolini, A. (2001). Promise and pitfalls in the use of" secondary" data-sets: Income inequality in OECD countries as a case study. Journal of economic literature, 39(3), 771-799.

Baumol, W.J. 1967. “Macroeconomics of Unbalanced Growth: The Anatomy of Urban Crisis.” American Economic Review 57: 415–426.

Berthe, A., Elie, L., 2015. Mechanisms explaining the impact of economic inequality on environmental deterioration. *Ecological Economics*, 116, 191–200.

Borghesi, S., 2006. Inequality and the Environmental Kuznets Curve. In: Basili, M., Franzini, M., Vercelli, A. (Eds.), Environment, Inequality and Collective Action. Routledge, Taylor & Francis Group, London & New York, pp. 33–51.

Boyce, J.K., 1994. Inequality as a cause of environmental degradation. Ecol. Econ. 11, 169–178.

Casey, G., & Galor, O. (2016). DP11659 Population Growth and Carbon Emissions.

Galeotti, M., Lanza, A., & Piccoli, M. C. L. (2011). The demographic transition and the ecological transition: Enriching the environmental Kuznets curve hypothesis. Centro Euro-Mediterraneo per i Cambiamenti Climatici (CMCC).

Gassebner,M., Gaston, N., Lamla,M.J., 2008. Relief for the environment? The importance of an increasingly unimportant industrial sector. Econ. Inq. 46, 160–178.

Grossman, G. M, Krueger, A.B., 1991. Environmental impacts of a North American Free Trade Agreement. *NBER Working Paper* 3914. Cambridge, MA: National Bureau of Economic Research.

Grunewald, N., Klasen, S., Martínez-Zarzoso, I., & Muris, C. (2017). The Trade-off Between Income Inequality and Carbon Dioxide Emissions. *Ecological Economics*, *142*, 249–256. https://doi.org/10.1016/j.ecolecon.2017.06.034

Heerink, N.,Mulatu, A., Bulte, E., 2001. Income inequality and the environment: aggrega- tion bias in environmental Kuznets curves. Ecol. Econ. 38, 359–367.

Hübler, M. (2017). The inequality-emissions nexus in the context of trade and development: A quantile regression approach. *Ecological Economics*, *134*, 174–185.

Jenkins, S. P. (2015). World income inequality databases: an assessment of WIID and SWIID. The Journal of Economic Inequality, 13(4), 629-671.

Magnani, E., 2000. The Environmental Kuznets Curve, environmental protection policy and income distribution. Ecol. Econ. 32, 431–443

McAusland, C., 2003. Voting for pollution policy: the importance of income inequality and openness to trade. J. Int. Econ. 61, 425–451.

Ravallion, M., Heil, M., Jalan, J., 2000. Carbon emissions and income inequality. *Oxford Economic Papars*, 52, 651–669.

Richard T. Carson; The Environmental Kuznets Curve: Seeking Empirical Regularity and Theoretical Structure, Review of Environmental Economics and Policy, Volume 4, Issue 1, 1 January 2010, Pages 3–23

Shafik, N., Bandyopadhyay, S., 1992. Economic growth and environmental quality: Time series and cross country evidence. *World Development Working Paper* WPS 904. Washington, DC: World Bank.

Torras,M., Boyce, J.K., 1998. Income, inequality, and pollution: a reassessment of the environmental Kuznets Curve. Ecol. Econ. 25, 147–160

Vollebergh, H., and C. Kemfert, 2005. "The Role of Technological Change for a Sustainable Development." Ecological Economics 54: 133–147.

You, W.-H., Zhu, H.-M., Yu, K., & Peng, C. (2015). Democracy, Financial Openness, and Global Carbon Dioxide Emissions: Heterogeneity Across Existing Emission Levels. *World Development*, *66*, 189–207.