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The inequality-emissions nexus in the context of trade and development: A quantile regression approach

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ABSTRACT

If the emissions attributed to households' consumption rise in their income in a concave way, higher within-country inequality will reduce emissions. To test this negative nexus, the article utilizes simultaneous-quantile regressions with per capita CO_2 emissions (or energy intensities of GDP) as the dependent variable and draws on country-level panel data. Overall, the estimates vary considerably across quantiles. Regressions with pooled data support the negative inequality-emissions (energy) nexus, whereas regressions with fixed-effects question it. International trade and international investments are mostly positively related to emissions (energy).

1. Introduction

During the last decades most countries have become richer, and some of the poorer countries have been able to catch up closer to the richer countries (Khan and Hudson, 2014). At the same time, within-country inequality has increased in many countries and triggered controversies and protests (Chin and Culotta, 2014). Obviously, high inequality is *per se* not desirable: it increases the risk of social tension and incentivises poverty-driven emigration. Notwithstanding, rising within-country inequality may have side effects, for instance in the environmental domain, that have not yet been sufficiently understood.

The Environmental Kuznets Curve (EKC) hypothesis postulates an inverted U-shaped relation between per capita income and per capita emissions and has been frequently studied.[1] The economic appeal of the EKC is the presumed automatism driving down emissions during the course of economic development, possibly supported by international trade and investments.[2] The EKC, however, deals with countries' aggregate income, whereas the connection between income distribution and emissions is hardly researched and controversial. Hence, the following article addresses the inequality-emissions nexus from a conceptual and econometric point of view. Given the urgency of the climate change challenge, the following article relates countries' per capita CO_2 emissions, or alternatively energy intensities, to within-country inequality.[3] Deeper insights in

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[1] The original Kuznets Curve hypothesizes going back to Kuznets (1955) postulates an inverted U-shaped relation between per capita income and inequality. For the EKC version, Selden and Song (1994) (page 147) find four possible explanations: "(i) positive income elasticities for environmental quality; (ii) changes in the consumption of production and consumption; (iii) increasing levels of education and environmental awareness; and (iv) more open political systems."

[2] It is debatable, whether due to declining emissions intensities, total emissions will approach zero in the long-term or keep on growing along with economic growth (Perman et al., 2011 chapter 2).

[3] Energy efficiency improvements are one of the most important measures to reduce CO_2 emissions (cf. Pacala and Socolow, 2004). Hübler and Keller (2010 page 63) note: "Although the EKC is a well-known concept and is regarded as a stylized fact in environmental economics, its existence has recently been challenged on both theoretical and empirical sides (e.g., Stern, 2004; Siebert, 2005). The EKC has traditionally been applied to emissions of local pollutants, but recent studies have also applied this concept to CO_2 emissions (e.g., Mazzanti et al., 2006 [authors' note: more recently published as Musolesi et al., 2010]) as well as energy intensity (Galli, 1998)."

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this nexus can be relevant for policy makers, especially in emerging economies, as well as for climate-economy modellers.[4]

Few scholars have studied the inequality-environment nexus and found contradicting results. Boyce (1994) argues that greater equality of power and income between beneficiaries of and sufferers from environmental degradation reduces environmental degradation. Torras and Boyce (1998) empirically confirm this argument for several pollutants but do not take into account CO_2. Though Scruggs (1998) challenges their findings both on the theoretical and the empirical side. Magnani (2000) finds that higher income equality has a positive effect on public research and development (R&D) expenditures of OECD[5] countries. She argues based on the median voter's preference for environmental amenities and a utility function depending on relative income. Likewise, Baek and Gweisah (2013) find that higher equality reduces CO_2 emissions in the short- and long-term in the United States.

On the opposite, Ravallion et al. (2000) and Heerink et al. (2001) show that higher inequality across households can reduce aggregate environmental degradation. Using cross-country data, Heerink et al. (2001) find that higher inequality indeed significantly reduces CO_2 emissions. Borghesi (2006) confirms Ravallion et al.'s (2000) previous outcome that higher inequality within countries significantly reduces CO_2 emissions in regressions with pooled panel data and shows that this result does not hold in regressions with fixed-effects. Nikodinoska and Schröder (2016) find that higher taxes on German car fuels raise inequality but dampen emissions.

On the conceptual side, the following article draws on Ravallion et al. (2000) and Heerink et al. (2001) by explaining the economic mechanisms that can lead to a concave or convex relation of emissions attributed to households' consumption to their income (technology argument) and by illustrating the connection between the micro- and macro-economic EKC (aggregation argument). It argues accordingly, given a concave (convex) micro-economic relation, rising inequality will ceteris paribus decrease (increase) macro-economic emissions ("rich and efficient" versus "poor and prudent").[6]

On the empirical side, the following article contributes to the literature dealing with the inequality-environment nexus by using a large up-to-date dataset of industrialized as well as developing countries and by including explanatory variables from the context of international trade and Foreign Direct Investment (FDI) (about 150 countries and the years 1985 until 2012 from World Development Indicators, 2014). It uses per capita CO_2 emissions or, as a new indicator in the inequality context, the energy intensity of GDP[7] as the dependent variable.

Whereas a few scholars have applied quantile regressions (Mills and White, 2009, Flores et al., 2014) or semi-parametric methods (Azomahou et al., 2006) to the assessment of the EKC hypothesis, this article applies them to the assessment of the inequality-emissions nexus and the trade/FDI-emissions nexus. In this way, emissions (or energy intensities) and their driving forces can be analyzed at different stages of countries' techno-economic development, represented by different quantiles of the conditional (emissions/energy) distribution.[8] To this end, a semi-parametric simultaneous-quantile regressions approach[9] will be utilized, which allows the direct comparison of the estimates for different quantiles. It also allows the non-parametric assessment of the EKC hypothesis without assuming a quadratic or cubic income-emissions relation (cf. Azomahou et al., 2006).

The results of the simultaneous-quantile regressions with pooled data suggest that *higher inequality reduces per capita CO_2 emissions as well as energy intensities* ("rich and efficient" case). Though panel estimations with country fixed-effects fail to yield a robust, significant inequality-emissions or -energy nexus.

The results underline the relevance of estimating the drivers of energy use and emissions at different quantiles, representing different stages of techno-economic development. The estimated elasticity of per capita CO_2 emissions (energy intensities) with respect to changes in the Gini index increases in the basic regressions from about -0.4 (-0.5) at low quantiles to about -1.2 (-1.5) at high quantiles. The estimated elasticity of per capita CO_2 with respect to GDP decreases from about 1.2 at low quantiles to about 0.9 at high quantiles. This result accords with the first phase of the EKC. For energy intensity as the dependent variable, on the contrary, the corresponding elasticities decrease from -0.1 to -0.4. For per capita CO_2 as a function of the trade intensity (openness), an inverted U-shape is found within the positive domain with statistically significant elasticities of 0.1 to 0.4 and the maximum located at the 60% quantile. A similar pattern is found for energy intensities with the maximum located at the 30% quantile. Evidence for energy or emissions savings via trade or FDI is at best found for the most energy-/emissions-intensive countries.

The article is structured as follows. Section 2 explains the inequality-emissions nexus and the econometric model. Section 3 describes the data, the methodology as well as the results of the different quantile regressions and discusses them. Section 4 concludes.

2. Framework

2.1. Inequality-emissions nexus

This subsection explains how households' income and economy-wide emissions are connected and based on this, in which direction and why higher inequality can affect economy-wide emissions (for a formal setup see the supplementary appendix).[10] We formulate three alternative hypotheses:

Hypothesis (1). *Households' contributions to the economy's emissions are concave in household income*. Equivalently, a household's emissions increase less than proportionally or decrease more than proportionally when the household's income rises ("rich and efficient" case). If inequality increases, i.e., ceteris paribus income is shifted from households with lower to households with higher income, economy-wide (per capita) emissions will decrease. This relation has formally been derived by Ravallion et al. (2000) and Heerink et al. (2001).

(i) Concavity will be supported if firms paying higher wages and returns on capital investments to households are at the same time more energy-/CO_2-efficient. This will be fulfilled when higher total factor productivity also reduces energy inputs. (ii) Concavity will be supported if households' consumption patterns and the resulting *direct CO_2 emissions* change with income in such a way that the induced *technique and composition effects* (cf. Grossman and Krueger, 1993) reduce the CO_2 intensity of the economy. For

[4] The integrated assessment community has recently begun to implement distributional aspects in the welfare functions of climate-economy models (cf. Dennig et al., 2016) while they have not been present in these models so far (e.g. Hübler et al., 2012).

[5] The Organisation for Economic Co-operation and Development.

[6] It is questionable whether the macro-economic EKC also holds at the micro-level. Hübler (2016), for example, identifies no EKC for deforestation activities of rural households in Southest Asia. He shows that not higher household income but education, higher relative affluence, younger age, self-employment and a higher value of assets significantly reduce deforestation.

[7] Gross domestic product.

[8] Section 3.1 (Fig. 3) provides descriptive statistics for selected countries illustrating that the emissions-inequality nexus differs depending on the per capita CO_2 emissions level (quantiles).

[9] This procedure generates a bootstrapped estimate of the variance-covariance matrix with between-quantile blocks (Stata, 2015, pages 2023ff.; Cameron and Trivedi, 2010, chapter 7).

[10] Inequality is measured at the micro-economic level based on households' (annual) income (or consumption) values (cf. World Development Indicators, 2014, the Gini index and its measurement). Wealth inequality is likely higher and not necessarily correlated with income (cf. Wolff and Zacharias, 2009, for the United States).