INEQUALITY AND THE ENVIRONMENT: THE SYNERGY OR THE TRADE-OFF EFFECT

Bianca PĂUNA[1]
Corina SÂMAN[2]

Abstract

The paper studies the relationship between inequality and environment in the case of the NMS of the European Union. We are interested in the sign of the effect in order to see whether there is an effect of synergy or trade-off between the two. We are also interested to analyse the extent of the bias if one analyses the production-based CO2 instead of the consumption-based CO2. The methodology is panel quantile regression, the independent variables introduced were GDP per capita, GINI coefficient, population growth, globalization, technology, renewable energy. With the exception of the GDP per capita and population growth the other variables negatively influence the emissions in almost all quantiles with the exception of 0.9 which has insignificant coefficients. The inequality coefficient is negative suggesting a trade-off effect, a reduce in inequality is increasing pollution, The results showed that analysing production-based CO2 emission results into a smaller elasticity of GDP, creating the impression that the effect of increases in the GDP are smaller than they are. The production-based emission coefficients in absolute value are systematically larger for poverty and renewable energy and smaller in the case of globalization, green innovation and technology.

Keyword: CO2 Emissions; Inequality; Panel Data Analysis

JEL Classification: C21, C52, Q56

1. Introduction

As country grow wealthier, they become more preoccupied with the environment and climate change, therefore, it is not surprizing that the EU is leading in climate change legislation and that in the ranking of the most environmentally friendly countries, according to the Environmental Performance Index[3], the first 24 countries are European. In 2020 EU managed to decrease its GFG emissions by 31% in contrast to its 1990's levels[4].

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[1] *Centre for Macroeconomic Modelling, NIER, Romania.* ***Corresponding author****. E-mail: bpauna@gmail.com*

[2] *Institute for Economic Forecasting, Romania. Email: csaman@ipe.ro*

3 *EPI is an index computed by the Centre for Environmental Law & Policy from the Yale University. It is computed by taking into account countries performance in climate change achievements, environmental health and ecosystem vitality. For more information see (Wolf, et al., 2022)*

4 *For more details see https://www.europarl.europa.eu/factsheets/en/sheet/72/combating-climate-change.*

The origins of environment legislation were established by the Single European Act of 1987, which opened the possibility of European environment policy. Since then the Commission issued Environment Action Programmes (EAP). The role of the EU was strengthened further by the Treaty of Maastricht in 1993, the Treaty of Amsterdam in 1999 and the Treaty of Lisbon in 2009 when fighting climate change become a specific goal for the EU legislation, and when EU received legal personality which opened the possibility for participating into international agreements. In 2019 EU adopted the European Green Deal with the goal to make Europe the first climate neutral continent in the world.

The latest EAP has six priority objectives, among which is the goal to achieve the 55% reduction in GHG by 2030 and climate neutrality by 2050; to "advance toward a regenerative growth model, decoupling economic growth from resources and environment degradation" and to "reduce environmental and climate pressures related to production and consumption (particularly in the areas of energy, industrial development, buildings and infrastructure, mobility and the food system"[5].

In order to reach the targets EU has set in place an Emission Trading System (ETS) on the principle that the pollutant should pay for its GHG emissions, and companies have to buy at action the rights for the specific quantities of CO2 they emit. The EU has set-up targets for air transport and maritime transport in terms of reducing pollution by including them into the ETS, and promoting the use of sustainable aviation fuels. In order to decrease pollution from road transportation, the EU has set up CO2 targets for cars and has banned the sale of new petrol or diesel cars by 2035. Other legislation deals with increasing the production of renewable energy, reducing energy consumption. Since heating and cooling of buildings account for 40% of energy consumption, the EU has introduced rules for new buildings in terms of energy performance[6],

Another EU action is the Effort Sharing Regulation, in which each member state has received its own target for GHG reduction to be achieved by 2030. The targets refer to several sectors[7], which made up 60% of GHG emissions, and are proportional to the wealth of the country, wealthier countries receive higher targets for CO2 reduction.

It is clear that European countries face stricter environment controls than other countries. Faced with that, they are obliged to reduce their GHG emissions, but they can choose one of the two most obvious strategies. First, they could change the technologies towards more efficient, less carbon intensive ones, which would imply high costs and higher prices for the end consumers. A second options could be to terminate the production of carbon intensive goods in the EU country and instead move the production abroad or import them from other countries. The second path is not without costs either, closing carbon intensive production facilities means people losing their jobs which is not a popular decision to make.

The EU acknowledge the possibility that a country is decreasing its GHG emissions at the cost of other countries increasing theirs and in October 2023 they introduced the Carbon Border Adjustment Mechanism which introduces for the first time a carbon-tax on imported goods, in order "to put a fair price on the carbon emitted during the production of carbon intensive goods

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5 For more details see https://www.europarl.europa.eu/factsheets/en/sheet/71/environment-policy-general-principles-and-basic-framework.

6 New building should produce 0 emissions by 2030, and have solar panels installed, to name only a few requirements.

7 The sectors covered by the Effort Sharing Regulations are domestic transport (excluding aviation), buildings, agriculture, small industry and waste.

that are entering the EU"[8]. The goods targeted will be carbon intensive goods whose production does not meet the EU restrictive policies on climate change.

The choice the country made is quite easy to observe if instead of analysing the GHG/CO2 production emissions, one analyses them in conjunction with the GHG/CO2 consumption emissions. The two data series differ from one another by the quantity of emissions embedded in the external trade, the figures are adjusted by the net emissions (emissions from imports minus emissions for exports).

Our paper will analyse the consumption versus production CO2 emissions in the New Member States, and check whether the income inequality in a country can impact the decision process.

2. Literature review

Since the world awareness towards the influence that the pollution with greenhouse gas (GHG) has on the climate, there is an exponential increase in the articles on this subject. It is acknowledged that most of the GDP growth was accomplished in the detriment of the environment because of the large dependence of the economies on energy and fossil fuels. The worry is that the decrease in greenhouse gas emission will be impeded by its relationship with the GDP, therefore, as long as GDP grows the air pollution would continue to rise.

Therefore, a large body of articles concentrate in studying the relationship between GDP and greenhouse gas emissions. Their aim is to determine the shape of the Environmental Kuznets Curve (EKC), which gives the relationship between either the GHG/CO2 and the GDP. The concept of EKC was introduce by (Grossman & Krueger, 1991) borrowing from Kuznets work on the inverted U shape relationship between income per capita and inequality (Kuznets, 1955).

The scope of the articles is to assess whether there is evidence that the positive relationship that occurs in most countries changes to a negative relationship at higher GDP per capita levels, a phenomenon that is known, in the literature, as decoupling. Some authors (Mikayilov, *et al*., 2018) make the distinction between the degree of decoupling absolute if the elasticity is negative, and relative if the elasticity is positive, but less than one.

The research is carried, in general, by including in the GHG regression besides the GDP variable its powers as well, in order to allow the relationship to be non-linear. The authors include at most the first, second and third power of the GDP, and depending on the significance and sign of the coefficients the results are interpreted as follows: only the first power significant means a linear relationship, and depending on the sign of the coefficient there might be a positive or negative relationship between the two variables. If the first and the second power coefficients are significant there is a quadratic relationship, a U shaped or inverted U shape, depending on the sign of the coefficients. If all three powers of the GDP are significant than the relationship is a N curve type. For a more detailed presentation of the EKC and the implications of the signs and values of the coefficients together with a summarization of papers estimating EKC, see for example (Leal & Marques, 2022), (Ajmi, *et al*., 2023).

A slightly different approach was employed in (Cohen, *et al*., 2022) where the authors used the Hedrick-Prescott and Hamilton filter to extract the long-term tendencies from the short-run cyclical fluctuations for both variables (GDP and CO2 emissions) and estimate a short term and long-term relationship for each of the countries studies in order to check if there is evidence on decoupling.

Due to the strong assumptions imposed by estimating the relationship between GHG/CO2 and GDP on a panel of countries, namely that the relationship between emissions and GDP is

8 For more details see https://taxation-customs.ec.europa.eu/carbon-border-adjustment-mechanism_en quadratic or cubic (depending on the number of powers of GDP included), and that the relationship is the same for all countries included in the cross-section and fixed over time, recent articles are using other methods to estimate the relationship between the variables of interest. Some example of more advanced econometric techniques used to study the change in the coefficients over time is quantile regression (Jebabli, *et al*., 2023), models with time varying coefficients (Mikayilov, *et al*., 2018), or neural network (Bennedsen, *et al*., 2023). The most frequent techniques used are panel estimators that address the cross-sectional dependency, endogeneity (Jiang, *et al*., 2022), (Hasan, *et al*., 2023), (Onofrei, *et al*., 2022)

An important topic that is not as studied as it should be is the difference between production-based and consumption-based emissions. When pressed to reduce their GHG/CO2 emissions businesses are faced with a choice to invest in cleaner technologies, or externalize the GHG/CO2 emission by importing the energy intensive product from a less developed country, so even if the domestic emission would seem to decrease in fact the consumption-based emissions are at best the same, at worst increased, due to the technological level of the less developed country. Examples of papers that are studying this aspect is (Mir & Storm, 2016), who showed on a panel of 40 countries that while the production CO2 shows signs of decoupling, the consumption CO2 is still coupled with the GDP.

Other group of analysis are broader in the sense that they investigate besides the effect of GDP on emissions the effect that other variables have on the emissions. (Aller, *et al*., 2021), (Jiang, *et al*., 2022), (Hasan, *et al*., 2023), (Onofrei, *et al*., 2022), (Patel & Mehta, 2023), (Xiong, *et al*., 2023), to name only a few studies.

Most studies would include besides the GDP (per capita), population (density) among the variables, since it is considered an important determinant of growth (Jiang, *et al*., 2022), (Xiong, *et al*., 2023), (Onofrei, *et al*., 2022), renewable energy consumption (Hasan, *et al*., 2023), (Nan, *et al*., 2022), some form of fossil fuel consumption or energy consumption (Baek & Gweisah, 2013) (Jiang, *et al*., 2022), (Hasan, *et al*., 2023), (Xiong, *et al*., 2023), (Patel & Mehta, 2023), (Aller, *et al*., 2021), (Sikder, *et al*., 2022), (Tan, *et al*., 2021), some form of savings and/or investment and/or foreign direct investment (Onofrei, *et al*., 2022), (Xiong, *et al*., 2023), (Tan, *et al*., 2021), a measure for green technology, measured typically by ratio of green patents in total patents (Jiang, *et al*., 2022), (Xiong, *et al*., 2023),

Other important variables include are urbanization (Aller, *et al*., 2021), (Sikder, *et al*., 2022), trade openness (Caglar, *et al*., 2022) (Hasan, *et al*., 2023), (Mir & Storm, 2016) since it can promote technology transfer, but on the other hand can ease the externalization of GHG/CO2 emissions through importing energy intensive products, financial development (Hasan, *et al*., 2023), (Patel & Mehta, 2023), (Tan, *et al*., 2021), (Xiong, *et al*., 2023), globalisation (Nan, *et al*., 2022) (Patel & Mehta, 2023), (Sikder, *et al*., 2022), energy production using fossil fuels (Aller, *et al*., 2021), (Hasan, *et al*., 2023), (Patel & Mehta, 2023), (Jiang, *et al*., 2022), (Xiong, *et al*., 2023), natural resources abundance measure (Caglar, *et al*., 2022),

Other articles use some specialized variables like political polarization or democratization (Aller, *et al*., 2021), industrialization (Aller, *et al*., 2021), (Sikder, *et al*., 2022). (Xiong, *et al*., 2023), resource abundance, public private partnership in energy, ECI (economic complexity index) (Caglar, *et al*., 2022).

For a more comprehensive literature review see (Aller, *et al*., 2021).

Among various variables that authors include to explain air pollution we are especially interested in income and inequality. The majority of studies include only a measure of income or per capita income neglecting the rest of the income distribution. (Dorn, *et al*., 2024) shows in a graph that the correlation between inequality and CO2 emissions depends on the income level of the country. High income countries exhibit a positive correlation, which means that high inequality is associated with high emissions, while middle and low-income countries exhibit a negative correlation, showing that high inequality might be associated with low emissions, suggesting that not only the level of income determines the air pollution of a country, but also that inequality plays a decisive role.

There are several explanations regarding the source of the relationship between income inequality and pollution. The first view originated in (Boyce, 1994), who described environmental degradation as the outcome of the struggle between the winners and losers who bear the costs, and depending on their relative power the outcome can be positive or negative. Since it is assumed that wealthier persons have more political power, and are less concerned about the environment because they gain benefits from pollution. A society with larger inequality is more likely to suffer from environmental degradation then a more equal one.

Another approach to explaining the relationship between inequality and environmental degradation is named by (Jorgenson, *et al*., 2017) as “propensity to emit” and the argument is that the preferences for carbon intensive goods is not constant, it varies with the level of income, and hence, changes in income will in turn change the pollution level of a country.

The literature on income inequality represented by the GINI coefficient, which is the approach that prevails in the literature, presents both possible correlations between poverty and carbon emissions, the positive as well as the negative one, as well no correlation at all.

When the relationship between inequality and emissions is positive, there are synergy effects between the two, because decreasing one helps to decrease the other as well. High inequality means that the income is concentrated in few hands, and because income equals political power in most cases, they can dictate what policies the country should pursue. Rich people are considered to prefer to consume status goods which in general are carbon intensive. If the rich population do not care for the environment which is the hypothesis most common in the literature (Dorn, *et al*., 2024), because they are able to avoid facing the consequences of climate change, then the higher the inequality the higher the air pollution.

The synergy effect is reinforced by poor people as well since they strive to emulate the behaviour of rich people. On the other hand, high pollution leads to extreme weather which results in draughts, inundations, fires, tornadoes, all with devastation impacts on the poor population of the country, with an effect of increasing the inequality.

If the relationship between pollution and inequality is negative than there is a trade-off between the two, you can not decrease emissions without affecting income inequality and vice-versa. In the literature they discuss about an individual Kuznets curve, which is an inverse U curve, with both very poor people and very rich people’s emissions very small. Very poor people because they mostly do not have access to electricity, and rich people, because they made a decision to reduce their carbon footprint. Under these assumption one would obtain a negative relationship between inequality and pollution. The same result can be explained if one considers the negative relationship between income and emissions represented by the environmental Kuznets curve. Most economists agree that in most cases economic growth is associated with a reduction in inequality, but conform EKC with an increase in carbon emissions, hence decrease in inequality might lead to the increase in air pollution.

(Borghesi, 2006) considers that the empirical dependence between inequality and pollution obtained in previous papers is only a product of the chosen estimator, which is pooled OLS. They estimated a model for the CO2 emissions where the explanatory variables were GDP per capita, population density, value added in industry, and inequality both by pooled OLS and a fixed effect model, on a set of 126 countries. When running the fixed effect model the authors obtained an insignificant coefficient for the inequality, even when they split the sample into high and low-income countries.

(Jorgenson, *et al*., 2017) investigated the relationship between inequality and pollution measured by the CO2 at the state level in the USA. As measure of inequality they used two variables the income share of the top 10%, and the GINI coefficient. They obtained a positive relationship between the income share of the wealthiest 10% of the population and CO2 emissions and no relationship between the GINI coefficient and the emissions.

(Dorn, *et al*., 2024) used a copula regression to investigate the relationship between income inequality and carbon emissions on a panel of 109 countries. They used several control variables to condition the relationship, GDP per capita, the value added in manufacturing, services and agriculture, the ratio of urban population in total, a measure of political framework and the share of fossil energy in total energy, The results suggested almost no dependence between emissions and inequality for high-income countries and a negative relationship for middle-and low income countries.

(Padilla & Serrano, 2006) used the instruments which are typical for income inequality analysis and applied it to the relationship between income inequality and inequality in emissions across countries. A first observation is that the majority of countries are still in the positive relationship between emissions and income part of the EKC. With respect to CO2 inequality and income inequality they consistently observed that CO2 inequality is larger, but it is decreasing over time.

(Kusumawardani & Dewi, 2020) applied and autoregressive distributed lag model for studying the relationship between inequality and CO2 emissions for Indonesia. Other explanatory variables included were GDP per capita, urbanization, and dependency ratio. The authors found a negative relationship between inequality and emissions both in the short term and long term, but the effect depends on the level of the GDP, since the interaction term between inequality and GDP was significant, but positive.

(Grunewald, *et al*., 2011) examine the relationship between income inequality and carbon emissions on a panel of 138 countries. They found that the income level of a country negatively affects the emission level, in the case of wealthy countries, with high income inequality there were smaller emissions of CO2.

In a later paper, the authors extended their analysis to control for the possibility of different relationship between inequality and emissions depending on the income. (Grunewald, *et al*., 2017) estimated the dependence between the two variables using a panel fixed effect model separately for low, middle and high-income countries. They found for low and middle-income countries a negative dependence between the two, namely high-income inequality is associated with lower pollution, while the opposite is true for high income countries, high income inequality is associated with high pollution, which is in contradiction with the result obtained in their previous article.

(Wu & Zihan, 2020) studied the relationship between inequality and emissions on a panel of 78 countries, which were grouped into three categories OECD countries, low-income non-OECD countries and high-income OECD countries in order to study the relationship separately. The authors found evidence of a cointegrations relationship between income inequality and emissions. Both in the OECD countries and high-income non-OECD countries the relationship is negative: high inequality promotes a reduction in emissions. The same relationship was absent from the low-income non-OECD countries because the coefficient on inequality was insignificant.

(Uddin & Mishra, 2020) analysed the relationship between income inequality and pollution on a panel of G7 countries over a long period 1870-2014. They used a non-parametric panel model since it allowed for time-varying coefficients. They found that the relationship between the two variables varies over time, at the beginning of the interval they uncover a positive effect between the two, a negative effect in the period 1950-2000, and no effect in the rest of the period (1881-1949 and 2001-2014).

3. Data and methodology

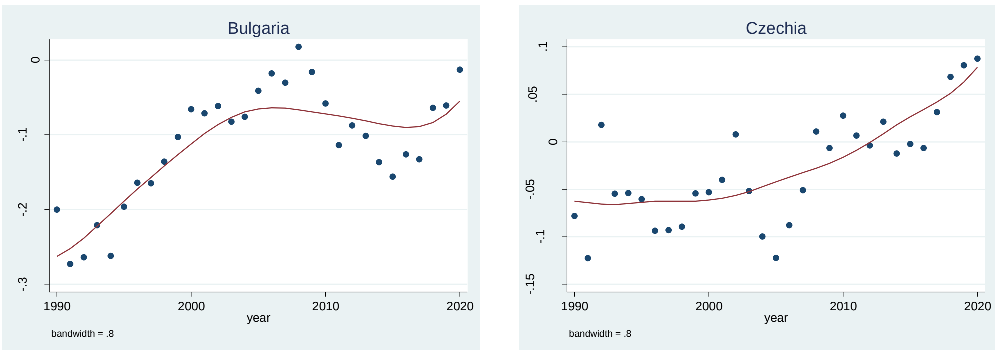
3.1. Data

We have used several sources for our data. One of the sources is the World Development Indicators published by the World Bank, the second is the site Our World in Data. For the Gini index of disposable income we used Standardized World Income Inequality Database (SWIID Version 9.6, December 2023), which is an extended database developed by Frederick Solt (a description of the database and the methodology used is presented in Solt, 2020). The Globalization index (KOF) was extracted from the OECD statistics, and the income share of the percentile 90 of the income distribution from World Inequality Database.

The countries covered by this paper are the New Member States of the EU which are Bulgaria, Croatia, The Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovenia and Slovakia. The data covers the period 1990-2022, but data for the newly created states is only from 1995. We used production as well as consumption-based CO2 emissions in order check how do the countries adjust to the stringent EU environment legislation.

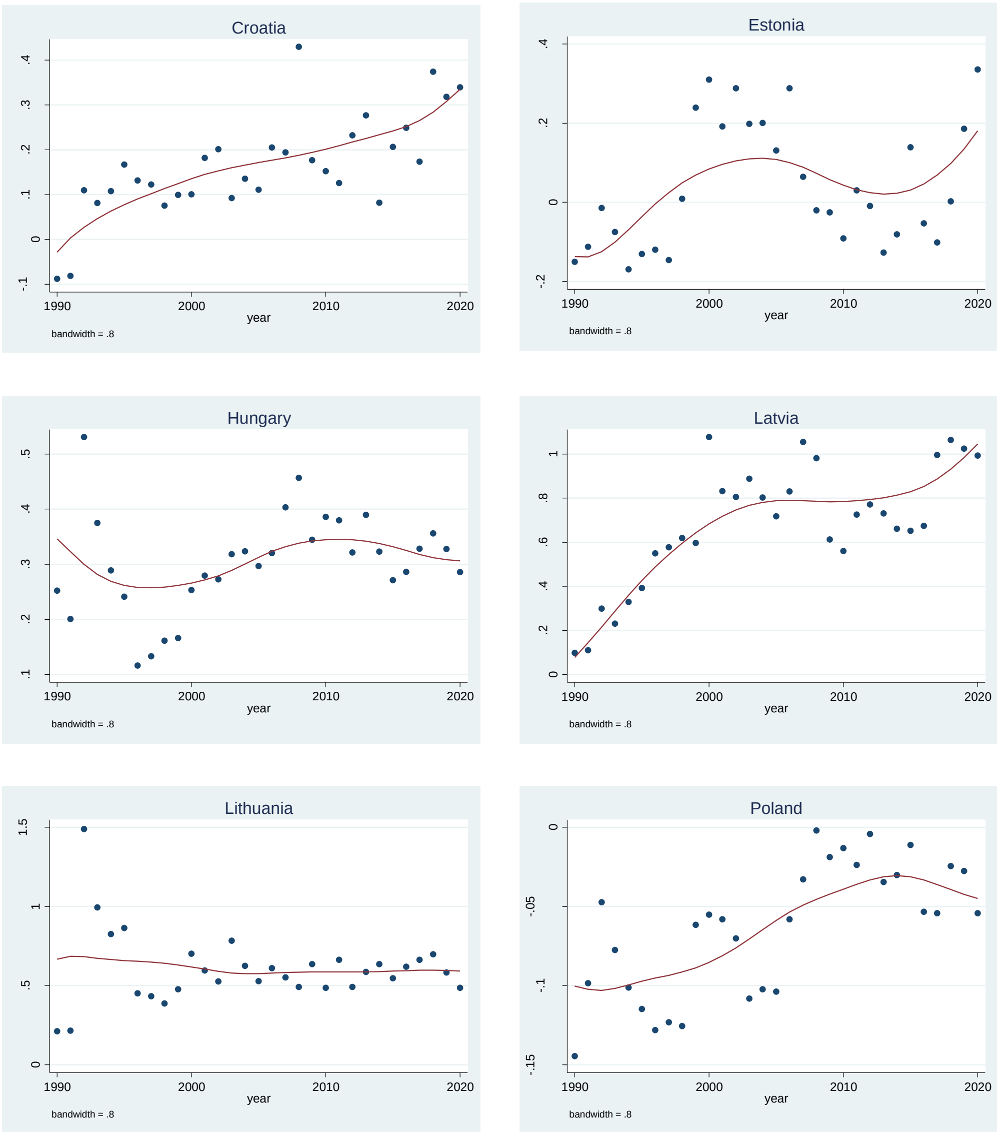
The production-based CO2 refers to the CO2 generated within the geographical border of the country, while the consumption-based measure is adjusted to take into account only the CO2 embodied into the commodities which are consumed in the countries. The difference in the two comes from the CO2 embedded into the net imports of the country. The percentage difference between consumption and production-based CO2 is an indicator of the path countries chose in order to adjust.

Figure 1. The percentage change of the difference between consumption and production based CO2 emissions by year and country



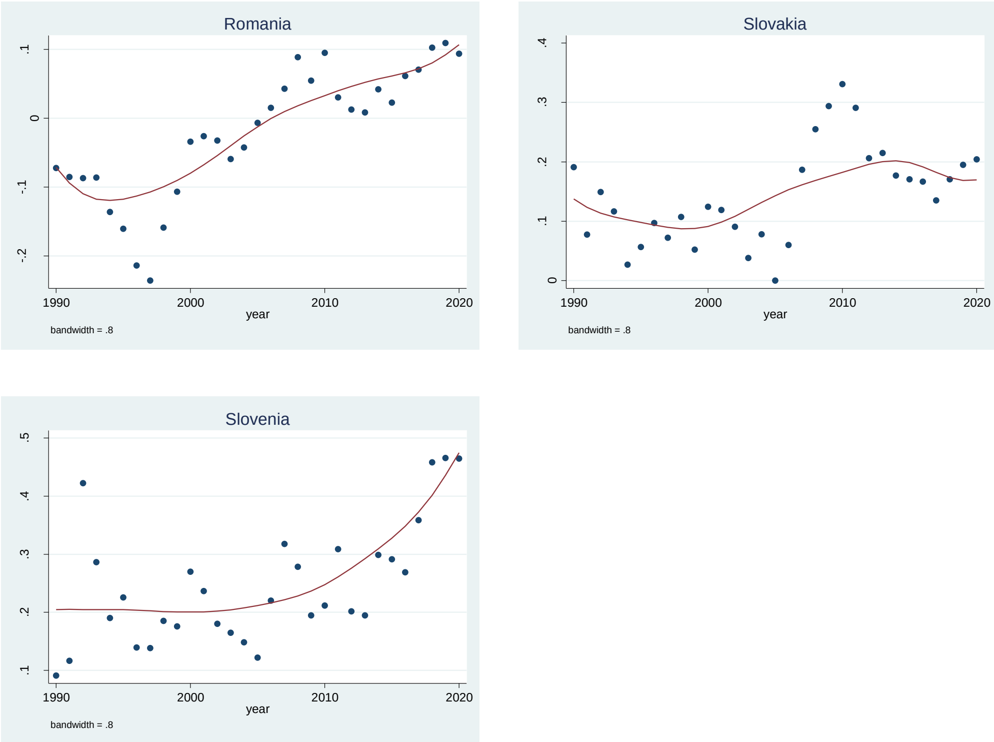
Source: Authors' computations.

Figure 2. The percentage change of the difference between consumption and production based CO2 emissions by year and country (cont.)



Source: Authors' computations.

Figure 3. The percentage change of the difference between consumption and production based CO2 emissions by year and country (cont2.)



Source: Authors' computations.

Figure 1 presents for each country the scatter-plot of the values of the percentage difference between consumption-based CO2 emissions and production-based CO2 emissions by year, together with a non-parametric estimator of the evolution of the variable. A positive value means that a country consumes more than it produces, so it imports the difference. A negative value means a country produces more than consumes and therefore exports the difference. Countries that are net exporters of CO2 are Bulgaria (with the exception of one year around 2010) and Poland. Countries that are net importers of CO2 are Croatia, with the exception of the first years (1990 and 1991), Hungary, Latvia, Lithuania, Slovakia and Slovenia. Romania, The Czech Republic and Estonia are both net exporters and net importers of CO2 during the analysed time interval.

3.2. Methodology

This paper uses the quantile model for panel data with nonadditive fixed effects introduced by Powell (2016) to see if the determinants of CO2 emissions have different effects at different quantiles of the conditional distribution of the emissions. This model account for unobserved individual level heterogeneity and includes fixed effects. The choice of this model is based on the fact that the estimates are consistent for small T when heterogeneous fixed effects are considered, which is important in our case (t=26 or 30).

To derive the estimates we use a Markov chain Monte Carlo (MCMC) algorithm with all-at-once sampling with 10000 draws and 1000 burn-in.

We estimated two models, the dependent variables are the CO2 emissions computed by the consumption method and CO2 emissions computed by the production method. The first variable introduced is GDP per capita. We are interested to analyse two aspects, first if there is any evidence that the CO2 emissions are decoupled from the GDP for the NMS analysed. Second, we are interested to see how the results are different if one compares the CO2 consumption vs. production emissions data. (Mir & Storm, 2016) found that while the production-based CO2 emissions shows signs that they are decoupled from GDP, the consumption-based CO2 emissions are not.

Another important variable we use is the Gini coefficient as a measure of inequality. In the literature the results of emissions and inequality are quite diverse. Some authors (Borghesi, 2006) on a panel of countries, (Dorn, et al., 2024) in the case of high-income countries, (Jorgenson, et al., 2017), (Wu & Zihan, 2020) in the case of low-income and non-OECD countries found no relationship between the Gini coefficient and emissions. (Padilla & Serrano, 2006) found a positive relationship between the Gini coefficient and inequality and (Jorgenson, et al., 2017) found a positive relationship between the share of the top 10% income and inequality. (Dorn, et al., 2024) in the case of middle and low-income countries, (Kusumawardani & Dewi, 2020) for Indonesia, (Grunewald, et al., 2011) on a panel of countries, (Wu & Zihan, 2020) in OECD countries and high-income non-OECD countries a negative relationship,

We included also population growth. The expectation is that population growth increases pollution, but in the literature the results are mixed. (Aller, et al., 2021) found a positive influence of the urban population on emissions, (Jiang, et al., 2022) found a negative effect of population density on emissions, and (Onofrei, et al., 2022) a negative effect of population growth on emissions.

Another variable of interest is globalization. Its sign can be both positive or negative, since globalization provides an escape for economies reluctant to change to greener technologies since it provides easy access to imports of high CO2 intensive commodities, on one hand, but also facilitates access to greener technologies. (Patel & Mehta, 2023) found that the globalization has a significant negative effect on emissions, and (Nan, et al., 2022) found that with the increase in globalization the effect of renewable energies become stronger, hence a negative relationship between globalization and emissions.

Green technologies and technological innovation are important variables which shows a nations predisposition for reducing its pollution, therefore it is expected that they contribute toward reducing pollution. (Jiang, et al., 2022) found a negative coefficient of their influence on pollution, (Xiong, et al., 2023) found that innovation has a significant negative effect on CO2 emissions. The innovation in green technologies was quantified by the number of green patterns in total number, and the technology level was quantified by the by the percentage of medium and high-tech exports in total.

Most paper include either a measure of energy produced with fossil fuels or a measure for renewable energy production, we choose to include the renewable energy consumption as percentage of total energy consumption. There is no ambiguity regarding the sign of the coefficient, renewable energy should decrease the use of fossil fuels and therefore reduce pollution.

We introduced in the regression an interaction dummy between the GDP per capita and a dummy which is one when CO2 computed by the consumption method is greater than CO2 computed by the production method, and zero otherwise, population growth,

4. Results

The distributional impacts of GDP per capita, poverty and the other control variables on CO2 emissions are presented in figures 2- 8. The left panel plots coefficients estimates and (95% confidence interval[9] for consumption-based emissions and the right panel plots estimates for production-based emissions.[10] For clarity, in all figures coefficient estimates are reported for the quantiles[11] 0.1 to 0.8 in 0.1 intervals excluding estimates for the 0.9 quantile which are statistical insignificant for all variables.

An important finding is that estimating the relationship between the production-based CO2 emissions and the GDP is not providing the correct picture, the coefficient for the elasticity of GDP with respect to consumption-based CO2 emissions is consistently higher. Interesting is that as we move to higher quantiles of pollution, the elasticity of GDP decreases, becoming non-significant for the 0.9 quantile, and the 0.8 quartile's elasticity is less than 0.4 of the elasticity of the lowest quantile.

The next coefficient is introduced to differentiate between countries that are importing goods intensive in CO2 (consumption-based emissions are greater than production-based emissions) and exporting goods which are intensive in CO2. It is an interaction dummy between the GDP per capita and a dummy which is one when CO2 computed by the consumption method is greater than CO2 computed by the production method, and zero otherwise, therefore the coefficient is applicable only to countries which are net importers of carbon intensive goods. The coefficient is significant almost for all quantiles indicating that the GDP elasticity of an importer versus exporter of carbon intensive goods are significantly different, all else equal. countries importing carbon intensive goods tend to have smaller elasticities of GDP with respect to emissions, but the differences are not very important, less than 1%. Again, we find evidence of heterogeneity in GDP per capita responses.

The main finding from figure 3 is that inequality, quantified with the help of the Gini index has a negative effect throughout the CO2 emission distribution (for both consumption-based and production-based) whenever the coefficient estimate is statistically significant. The coefficient is smaller for the middle quantiles, where there is the largest differences between consumption and production-based estimates. For the NMS there is a trade-off between the pollution and inequality. We find evidence of substantial heterogeneity in poverty responses, especially for consumption-based emissions.

The coefficient on the growth of the population has a positive effect on the emissions, and the influence of population growth on emissions becomes stronger for higher quantiles. Since Europe experiences a negative population growth this variable also contributes toward the decrease in emissions.

Globalization is another variable which helps to reduce pollution. Its effect is mostly negative and significant, and increasing with the increase in the quantile. Next two variable are discussed together because they both represent the technology of the country, first variable quantifies the green innovation since it is the percentage of green patents out of the total, and the second the level of the technology because it is the share of medium and high technology exports in total exports. The innovation variable should be included with lags since it takes time for a technology to be applied after the patent. Due to the insufficient number of observations we choose to use the current variable. Both variables have the expected negative sign at smaller quantiles, but the

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[9] *Confidence interval and are calculated pointwise from the posterior of MCMC draws.*

[10] *Results are also presented in tables A1-A7 in the appendix.*

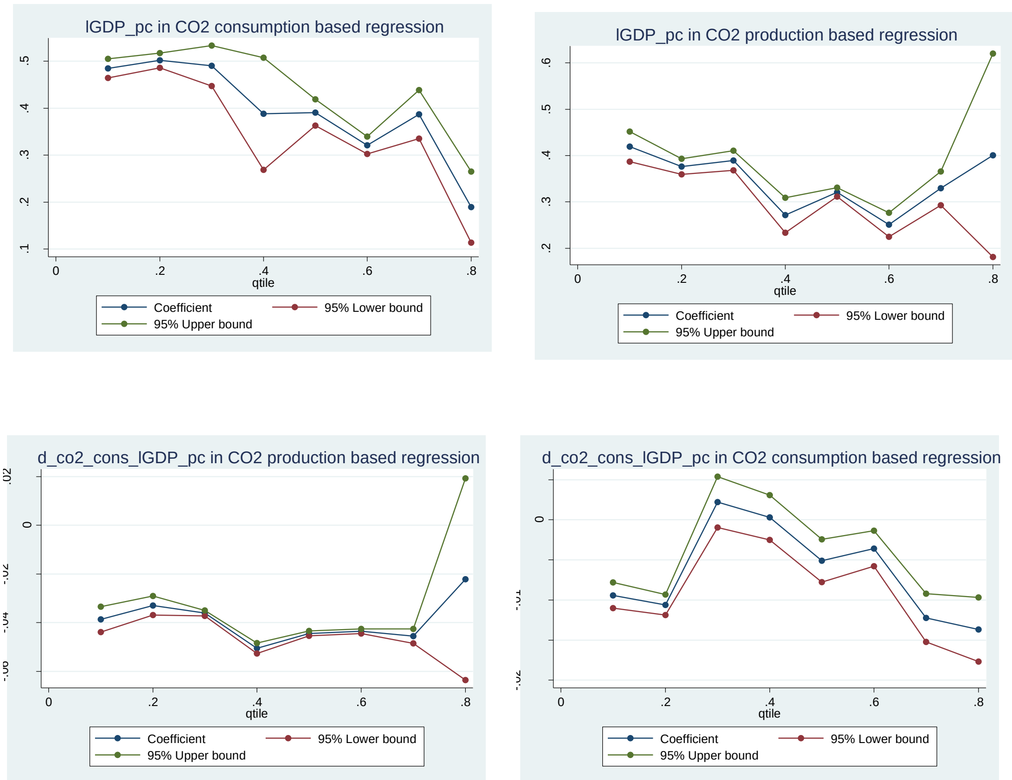
[11] *The quantiles on the x-axis refer to the CO2 emissions distribution.*

green innovation variable becomes positive at larger quantiles. The reason for the change in sign should be investigated further.

The renewable energy consumption is introduced mostly as a control variable since most studies include either renewable energy consumption or fossil fuel energy consumption. The coefficient has the expected negative sign, and shows that the higher the emission quantile the lower the influence that the renewable energy consumption has on emissions.

The production-based emission coefficients in absolute value are systematically larger for poverty and renewable energy and smaller in the case of globalization, green innovation and technology.

Figure 4. The distributional impacts of GDP per capita and interaction term

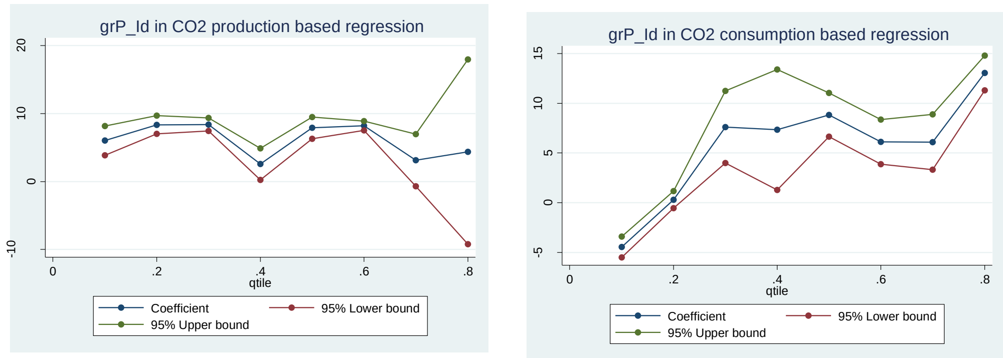


Source: Authors' computations.

Figure 5. The distributional impacts of Gini index

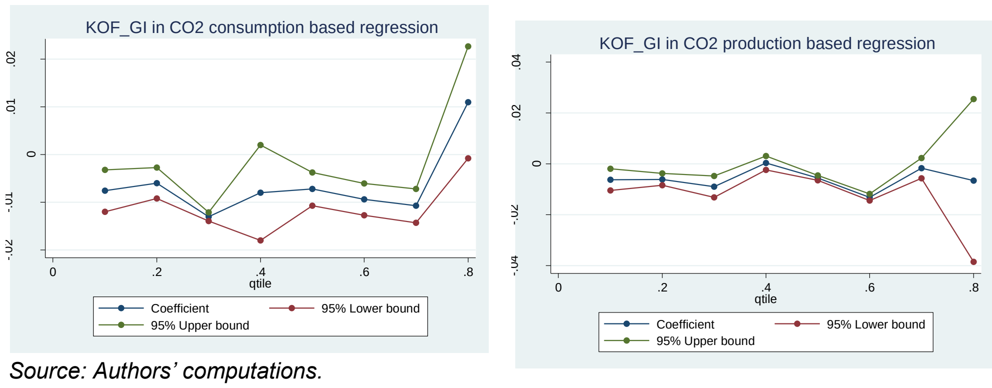
Source: Authors' computations.

Figure 6. The distributional impacts of population growth



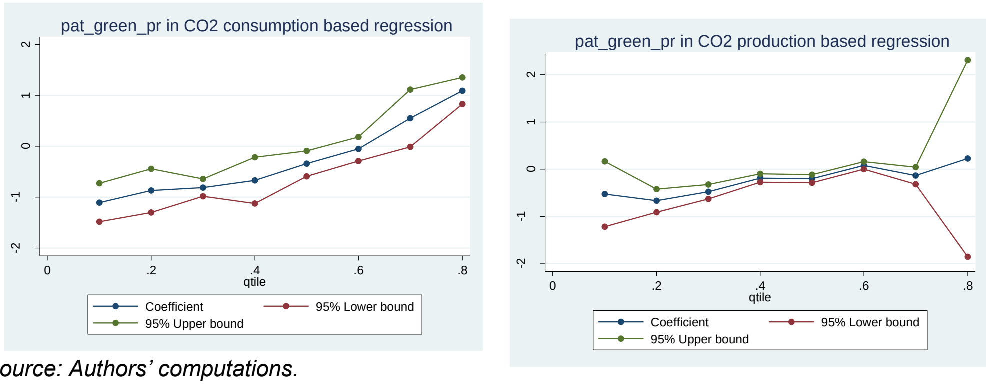
Source: Authors' computations.

Figure 7. The distributional impacts of globalization



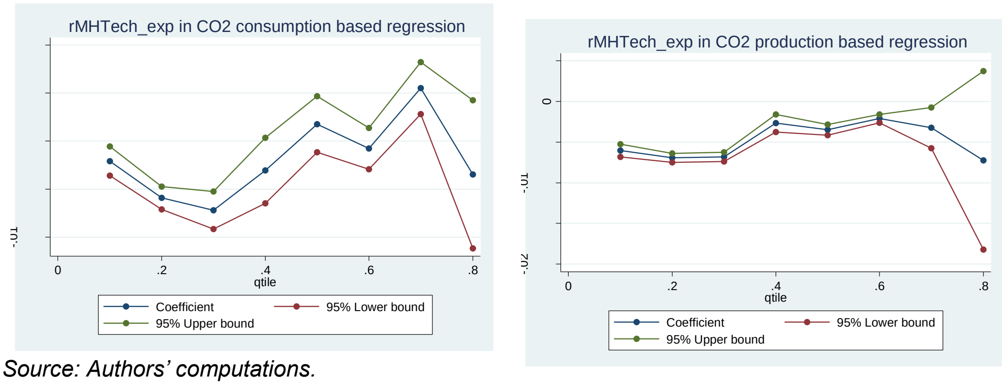
Source: Authors' computations.

Figure 8. The distributional impacts of green innovation (the percentage of green patents out of the total)



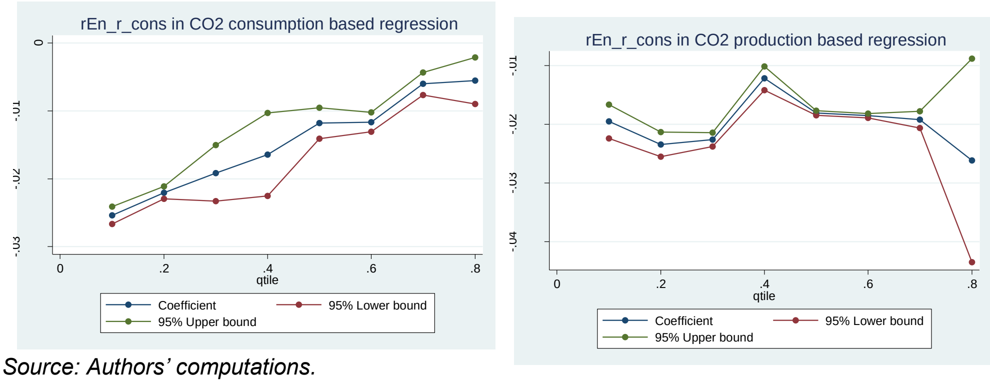
Source: Authors' computations.

Figure 9. The distributional impacts of the level of technology (the share of medium and high technology exports in total exports)



Source: Authors' computations.

Figure 10. The distributional impacts of the renewable energy consumption (the share in total energy consumption)



Source: Authors' computations.

Conclusions

This paper investigates the heterogeneity in the CO2 emissions effects of the inequality measured by Gini index of disposable income. We account for both heterogeneity and endogeneity using Powell's quantile estimator with fixed-effects.

Our findings showed the necessity to use consumption-based CO2 dependent variable in order to correctly ascertain the effect that different variables have on a country's footprint. Although the signs of the coefficients are in most cases consistent in the two models, the values are different. The absolute value of the coefficients from the production-based model are systematically higher for the elasticity of GDP, poverty and renewable energy and smaller in the case of globalization, green innovation and technology.

Second, the dependence between pollution and poverty is negative, showing that there is a trade-off effect between the two. The result is not surprizing since in general GDP growth is associates with decrease poverty and increased pollution, hence the negative relationship between the two, but it makes the process of decreasing pollution more difficult and unpopular.

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