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Income Inequality as a Barrier to the CO_2-Reducing Impact of Public Investment: Evidence from Latin America

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Keywords: Carbon intensity; public investment; income inequality; Latin American countries.

JEL Codes: C33, E22, O54, Q52.

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1 Introduction

The relationship between economic growth and environmental impact has long been the subject of extensive debate. Grossman and Krueger (1995) argue that in the early stages of development, economic growth tends to exacerbate environmental degradation, reflecting a growth trajectory heavily dependent on natural resources. In contrast, Dollar and Kraay (2002) contend that when growth is accompanied by reduced income inequality, it can significantly contribute to poverty alleviation. This is particularly relevant for developing countries, where a substantial portion of the population still lacks access to basic goods.

Broadly speaking, two principal strands can be identified in the literature concerning the relationship between income inequality and environmental outcomes. The first argues that reducing income inequality may result in increased emissions. This perspective is grounded in the Environmental Kuznets Curve hypothesis, which posits that environmental degradation tends to rise during the early stages of economic growth but eventually declines as income levels increase and technological improvements are adopted (Kaika and Zervas, 2013; Stern, 2018; Ali, 2023; Ye et al., 2023). Consistent with this view, the Marginal Propensity to Emit hypothesis suggests that lower-income households possess a higher marginal propensity to consume, thereby implying that redistributive policies may lead to greater demand for carbon-intensive goods and services (Fisher et al., 2020).

The second strand highlights an opposing mechanism, arguing that reducing income inequality can lead to improved environmental outcomes. In this view, the environment is treated as a normal good, for which demand increases alongside rising incomes (Scruggs, 1998). Empirical studies from diverse contexts—including the United States (Baek and Gweisah, 2013), China (Zhang and Zhao, 2014), and Sub-Saharan Africa (Baloch et al., 2020)—suggest that greater income equality is associated with lower emissions. These divergent findings underscore the context-dependent nature of the inequality–emissions relationship, which is shaped by consumption patterns, structural conditions, and regional heterogeneity.

Balancing economic growth, income distribution, and emissions reduction remains one of the foremost global challenges. International agreements have increasingly emphasized the need to align these three dimensions. The 17 Sustainable Development Goals (SDGs), adopted by the United Nations in 2015 and in effect since 2016, seek to simultaneously eradicate poverty, reduce income inequality, and protect the environment. These goals constitute the foundation of the global sustainable development agenda. Additionally, COP29, held in Baku in 2024, reaffirmed the principle of a just transition as a cornerstone of international climate policy. COP30, scheduled to take place in Brazil in 2025, is expected to advance these commitments by further integrating environmental objectives with social justice.

Amid this debate, the social dimensions of the climate crisis have gained increasing attention. Emerging evidence indicates a strong link between economic inequality and carbon inequality. Research shows that the long-term decline in the labor share of income, alongside rising personal and functional inequality, has contributed to poverty and economic instability (Brueckner and Lederman, 2018; Bergstrom, 2020; IMF, 2024). These trends have also exacerbated environmental disparities (Ederer and Rehm, 2020; Huwe and Rehm, 2022).

On the one hand, the unequal distribution of income contributes to increased carbon intensity in consumption. While low-income groups emit less in absolute terms, their consumption tends to involve goods and services with relatively higher emission intensity (Mittmann and Mattos, 2020; Theine et al., 2022; Ogede et al., 2022). Typical examples include inexpensive processed foods, older and inefficient fossil fuel-powered transportation, and electricity derived from non-renewable sources.

On the other hand, high-income groups are responsible for the majority of global CO_2 emissions relative to GDP (CO_2/GDP), not only due to the substantially larger volume of their consumption but also because their consumption patterns include highly carbon-intensive items, such as frequent air travel, large private vehicles, and high energy use associated with spacious housing. Their carbon footprints far exceed sustainable thresholds, both between and within countries (Lamperti et al., 2025). Furthermore, carbon pricing policies often exhibit regressive effects, disproportionately burdening low- and middle-income groups with the costs of mitigation (Huwe and Rehm, 2022).

According to Schöngart et al. (2025), in 2019, the richest 10% of the global population was responsible for nearly half of total emissions through private consumption and investments, while the poorest 50% accounted for only one-tenth. Similarly, in Brazil, the richest 1% of the population emits approximately seven times more carbon than the poorest 10% (Rodrigues et al., 2025). Moreover, within-country disparities in carbon emissions account for roughly two-thirds of global carbon inequality (Chancel et al., 2023).

Reducing income inequality is therefore essential to enabling a just and effective low-carbon transition.[1] Basic consumption, which is easier to decarbonize, tends to be relatively uniform across income groups. In contrast, more carbon-intensive luxury consumption is heavily concentrated among the wealthy (Oswald et al., 2021).

This study aims to estimate the effect of public investment on the CO_2/GDP ratio under conditions of relatively higher and lower income inequality in Latin American countries between 1994 and 2019. To achieve this, it applies a nonlinear Local Projections method using panel data, which captures heterogeneous effects over time and across different income inequality regimes. Several empirical studies support a positive relationship between income inequality and CO_2 emissions (Baek and Gweisah, 2013; Grudwald et al., 2017; Mittman and Mattos, 2020; Yang et al., 2022; Ogede et al., 2023; Fernandez et al., 2024; Lamperti et al., 2025). However, none of these studies have specifically investigated the relationship between public investment and emissions across different levels of income inequality.

Accordingly, this study makes two main contributions. First, it incorporates the distributional dimension into the analysis of the environmental impacts of public investment, helping to clarify the conditions under which fiscal policy can promote both social equity and environmental sustainability. Second, it employs a method that accounts for nonlinearities and regional heterogeneity (controlling for country fixed effects), thereby enabling more robust and context-specific policy recommendations for countries seeking to reduce both emissions and income inequality.

The results indicate that public investment effectively reduces emissions in contexts of relatively lower income inequality, whereas its impact is not statistically significant in higher-inequality settings. Specifically, a 10% increase in public investment leads to an approximate 4.40% reduction in carbon intensity, as measured by the CO_2/GDP ratio, after the fourth period in lower-inequality contexts. These empirical findings suggest that, in Latin American countries, the environmental effectiveness of public investment is significantly contingent upon the profile of income distribution.

The remainder of the paper is organized into five main sections following this introduction. The second section presents the theoretical framework, and the third outlines the data and methodology. The fourth section presents the empirical results, including the linear local projection estimates, the nonlinear specification, and robustness checks. The fifth section offers a discussion of the results, and the sixth recapitulates the key findings and provides final remarks.

2 Related literature

The relationship between fiscal policy and emissions has received growing attention in the economic literature, particularly concerning the role of public investment in reducing greenhouse gas emissions. Ex-

[1]The concept of a just transition has become an established international norm, as outlined in the 2015 Guidelines of the International Labour Organization (ILO) under the United Nations (UN). It aims to ensure that the shift to a low-carbon economy promotes equity, respects local communities, and supports higher wages, while also reducing the vulnerabilities faced by the poorest populations (see Morena et al, 2020).

isting empirical research suggests that fiscal expansions can help lower CO_2 emissions and the CO_2/GDP ratio through both production and consumption channels. Increases in public spending on social sectors such as education and health are linked to reduced emissions, while a more equitable income distribution appears to improve environmental quality (Baek and Gweisah, 2013; Halkos and Paizanos, 2016; Abbass et al., 2021).

In the same vein, empirical evidence underscores that income inequality not only undermines the social benefits of economic growth but also poses substantial challenges to its environmental sustainability. Research indicates that lower income inequality is generally linked to reductions in carbon emissions, while higher income inequality tends to exacerbate them. Nevertheless, the magnitude and direction of this relationship differ depending on the considered countries' income levels and institutional frameworks (Yang et al., 2022; Ogede et al., 2023).

For example, empirical studies indicate that in low- and middle-income economies, higher income inequality may be associated with lower average per capita emissions, whereas in upper-middle- and high-income economies, it tends to correlate with higher per capita emissions. This pattern arises because, in poorer and more unequal countries, a significant share of the population lives largely outside the carbon economy and contributes minimally to emissions. In contrast, wealthier countries exhibit a lower marginal propensity to emit among high-income groups, yet emissions remain elevated due to the outsized carbon footprint of the wealthiest segments of the population (Grunewald et al., 2017; Mittmann and Mattos, 2020; Lamperti et al., 2025). These findings underscore the importance of properly accounting for both the stage of economic development and the income share held by top deciles of the economies under investigation when analyzing the relationship between income inequality and emissions (Jorgenson et al., 2016).

Recent contributions to the literature have increasingly sought to integrate the two dimensions of public investment and income inequality, aiming to understand how income distribution contexts influence the environmental impact of fiscal policy. Fernandez et al. (2024) categorize countries into two groups based on income inequality (more and less unequal) and analyze variables such as energy efficiency, productivity, and agriculture. As a complementary finding, they show that in countries with lower levels of income inequality, public investment tends to reduce CO_2 emissions, whereas in highly unequal societies, this effect may be reversed. Similarly, Sanches et al. (2025) find that the impact of public investment on private investment also varies with the degree of income inequality: the crowding-in effect is observed only in contexts of low income inequality and becomes statistically insignificant in highly unequal settings. Table 1 summarizes the most recent studies exploring the empirical intersections between income inequality, fiscal policy, and emissions.

Complementing these findings, recent studies highlight the critical role of income inequality in shaping emissions dynamics at the macroeconomic level. Evidence from Theine et al. (2022) and Oswald et al. (2021) indicates that, while lower-income groups emit less in absolute terms, their consumption is relatively more carbon-intensive per unit of income. In contrast, higher-income groups are responsible for the largest carbon footprints, often exceeding globally sustainable thresholds by several multiples (Huwe and Rehm, 2022). Moreover, carbon pricing policies are typically regressive, disproportionately burdening the most vulnerable populations and thereby intensifying the distributive challenges inherent in the transition to a low-carbon economy (Dorband et al., 2019).

Despite these several advances, to the best of our knowledge, no study to date has estimated the impact of public investment on CO_2 emissions, and consequently on the CO_2/GDP ratio, across different income inequality regimes, specifically within the context of Latin America. Addressing this important gap, the present study contributes to the empirical literature by providing new evidence to inform fiscal policies that aim to jointly advance CO_2 emissions mitigation and distributive justice. After all, effective environmental policies pursued through public investment should aim not only to reduce emissions but also to foster a just transition to a low-carbon economy—one that ensures the equitable distribution of both the costs and benefits of climate action, meaning the collective efforts and policies to mitigate and adapt to climate change. In fact, a just transition to a low-carbon economy should avoid exacerbating income inequality and, ideally, contribute to its reduction. Our estimation results also shed light on how CO_2 emissions unequally affect the consumption patterns of both the wealthiest and the poorest segments of the population.

Table 1: Summary of empirical studies on income inequality, public spending and CO_2 emissions

Author(s)	**Country / Period**	**Methodology**	**Main Results**
Abbass et al. (2021)	Pakistan (1976–2018)	VAR model	Increased public spending in social sectors such as education and health is associated with emissions reductions.
Baek and Gweisah (2013)	United States (1967–2008)	ARDL model	More equitable income distribution improves environmental quality.
Fernandez et al. (2024)	22 European countries (2015–2020)	Cluster analysis	Productivity and emissions are negatively (positively) correlated in high-inequality (low-inequality) countries. Public investment is negatively correlated with emissions in low-inequality countries.
Grunewald et al. (2017)	158 countries (1980–2008)	Pooled OLS	In low- and middle-income economies, higher income inequality is associated with lower carbon emissions. In upper-, middle-, and high-income economies, higher income inequality is associated with higher per capita emissions.
Halkos and Paizanos (2016)	United States (1973–2013)	VAR model	Fiscal expansions can help reduce CO_2 emissions.
Jorgenson et al. (2016)	United States – 50 States (1997–2012)	Prais-Winsten regression model with PCSE	State-level emissions are positively associated with the income share of the top 10%. The effect of the Gini coefficient on emissions is non-significant.
Lamperti et al.(2025)	160 countries (1980–2018)	Fixed effects model	In more developed countries, there is a positive relationship between income inequality and carbon emissions, largely driven by the disproportionately high carbon footprint of the wealthiest 10% of the population.
Mittmam and Mattos (2020)	16 Latin American countries (1970–2013)	GMM model	Income inequality influences CO_2; however, the direction and magnitude of this impact depend on a country's income level.

Author(s)	Country / Period	Methodology	Main Results
Ogede et al. (2023)	32 Sub-Saharan African countries (2000–2018)	Cross-sectional ARDL and AMG	Income inequality contributes to higher emissions in both the short and long term; however, institutional quality can mitigate this effect.
Sanches et al. (2025)	Brazil (1996–2022)	TVAR model and LP	Public investment exhibits a crowding-in effect on private investment only in conditions of low income inequality, while no significant effect is observed under high income inequality.
Yang et al. (2022)	France and United States (1915–2019)	Wavelet decomposition and quantile-on-quantile regression	In France, low levels of income inequality are associated with reductions in carbon emissions. In the United States, rising income inequality initially intensifies emissions, although this effect diminishes over the long run.

Source: Authors' elaboration.

Note: VAR: Vector Autoregressive; ARDL: Autoregressive Distributed Lag; AMG: Augmented Mean Group; OLS: Ordinary Least Squares; PCSE: Panel-Corrected Standard Errors; GMM: Generalized Method of Moments; TVAR: Threshold Vector Autoregressive; LP: Local Projections.

3 Data and Methodology

3.1 Data

We used a panel dataset comprising Latin American countries (Argentina, Bolivia, Brazil, Chile, Costa Rica, the Dominican Republic, Ecuador, Guatemala, Honduras, Mexico, Panama, Peru, Paraguay, El Salvador, Uruguay, and Venezuela).[2] The variables were constructed as follows:

1. **Public investment:** Data were sourced from the Penn World Table (PWT). Nominal public investment, originally in local currency, was converted to purchasing power parity-adjusted US dollars (PPP-adjusted USD) and then divided by nominal GDP to calculate its share of the economy.

2. **CO_2 intensity:** The carbon intensity of the economy was measured as the ratio of CO_2 emissions to GDP, based on data from the EDGAR v7.0 Fossil CO_2 Emissions Database (2022).

3. **Gini index for disposable income:** This annual series was obtained from the Standardized World Income Inequality Database (SWIID) (Solt, 2020).

4. **Exchange rate, and inflation:** Extracted from the Global Macro Database (GMD), which compiles harmonized historical data from 113 sources, including the IMF, World Bank, and OECD.

5. **Commodity prices:** We used annual producer price data for agricultural commodities from the FAOSTAT database of the Food and Agriculture Organization (FAO) of the United Nations.

[2]Cuba, Colombia, and Nicaragua were excluded from the dataset owing to insufficient data availability during the 1994–2019 period.

6. **Industrial structure:** Data on the industrial structure were obtained from the World Bank's World Development Indicators (WDI). We used the variable *Industry value added* (% of GDP), which captures the share of the industrial sector in the total value added of the economy. This indicator is a structural control since economies with a higher industrial share tend to exhibit greater energy use and CO_2 intensity.

7. **Economic growth:** Real GDP per capita was calculated from PWT by converting GDP to PPP-adjusted USD and dividing by the total population.

8. **Share of Renewable Energy in Gross Domestic Supply** (%): This variable represents the ratio of renewable energy supply to total energy supply, calculated using data from the Energy Information System for Latin America and the Caribbean (sieLAC), and serves as a general proxy for the structure of the clean energy matrix.

3.2 Methodology

To estimate the dynamic effects of public investment on carbon intensity (measured as the CO_2/GDP ratio) across two income inequality regimes, we employed the Nonlinear Local Projections approach, originally proposed by Jordà (2005) and extended to panel data by Hartley and Mejia (2025).

The results were estimated for 16 Latin American countries under two regimes—characterized by relatively higher and lower income inequality—defined by an optimal threshold value of the Gini index, automatically determined as the one that maximizes the accumulated difference between the regimes in their responses to the public investment shock. The estimated equation for each horizon $h \in \{0, 1, 2, \dots, 6\}$ is specified as follows:

$$y_{i,t+h} = \alpha_i + \lambda_t + \beta_h \, pub_{i,t} + \gamma_h \, (pub_{i,t} \cdot D_{i,t}) + \delta_h' X_{i,t} + \varepsilon_{i,t+h}, \tag{1}$$

where $y_{i,t+h}$ denotes the dependent variable, measured as the CO_2/GDP ratio for country i at horizon $t + h$; α_i are country-specific fixed effects that capture time-invariant heterogeneity across countries, such as institutional characteristics or structural factors; λ_t are time fixed effects that control for global shocks or common trends affecting all countries simultaneously (e.g., financial crises or international energy price shocks); $pub_{i,t}$ represents the identified shock to public investment at time t, with its effect under lower income inequality regimes captured by β_h; $D_{i,t}$ is a regime dummy equal to 1 under higher income inequality and 0 under lower income inequality, allowing for heterogeneous effects, where the additional impact of the public investment shock in high-inequality regimes is captured by γ_h; $X_{i,t}$ is a vector of control variables with associated coefficients δ_h', accounting for additional macroeconomic conditions (such as exchange rates, inflation, GDP growth, the share of industry in value added, and share of Renewable Energy in Gross Domestic Supply); and $\varepsilon_{i,t+h}$ is the error term, capturing unobserved shocks not explained by the model (further methodological details can be found in Appendix A).

Panel unit root tests by Levin, Lin, and Chu (LLC), and Im, Pesaran, and Shin (IPS) were applied. The results indicated that the CO_2/GDP ratio is non-stationary in levels. To ensure the statistical validity of subsequent estimations, the variable was transformed into first differences. All variables were log-transformed prior to estimation.

Furthermore, to determine the appropriate number of lags for the shocks, a panel VAR model with fixed effects was estimated using the three main variables: public investment, carbon intensity, and income inequality. The optimal lag length was selected based on the Akaike (AIC), Bayesian (BIC), and Hannan–Quinn (HQIC) information criteria, which were calculated from the model residuals across lag lengths ranging from 1 to 4. Two lags were used as a control variable for public investment and CO2/GDP in the baseline exercise to control the persistence of these variables (Heimberger, 2020).

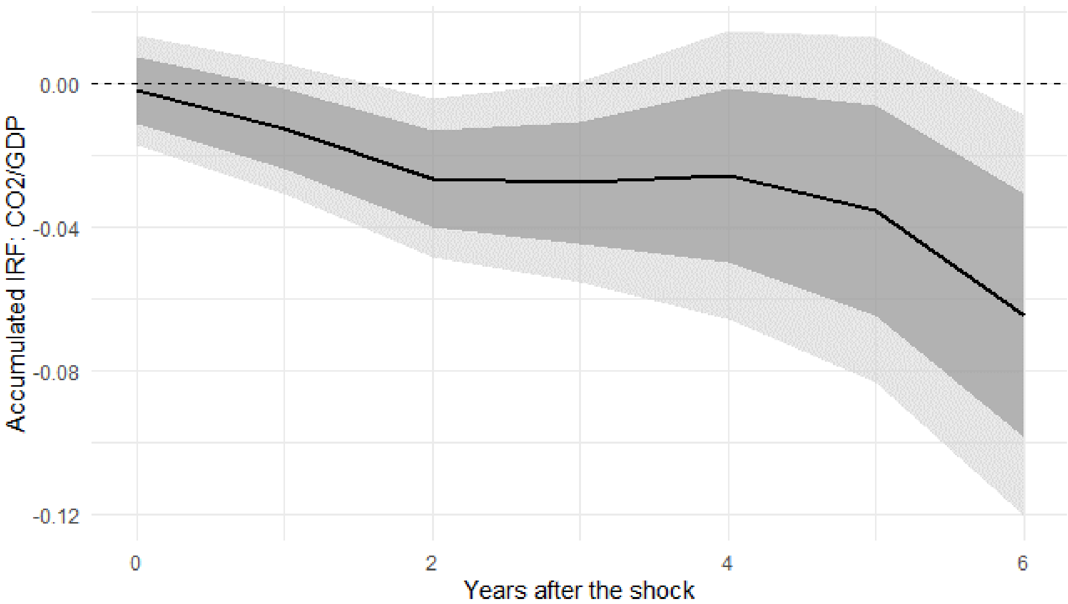
4 Results

4.1 Linear Local Projections

Before estimating the nonlinear model, preliminary estimations were conducted using the Local Projections approach. Three lags were included based on the AIC, BIC, and HQIC information criteria. The CO_2/GDP ratio and Gini variables were differenced to ensure stationarity, and fixed effects for country and year were incorporated. Initial results suggested that public investment exerts a cumulative negative effect on the carbon intensity of the economy (as measured by the CO_2/GDP ratio), as in Fernandez et al. (2024), while the Gini index (serving as a measure of income inequality) is positively associated with the same indicator, consistent with Ogede et al. (2023) and Lamperti et al.(2025).

In particular, as shown in Figure 1, the results of the linear model indicate that a shock to public investment cumulatively reduces the CO_2/GDP ratio over a period of up to six years following the shock, with negative coefficients at all horizons. Although statistical significance is limited in certain periods, the coefficients for years 2, 3, and 6 are significant at the 10% level, and the 68% confidence bands remain below zero for most of the horizon, indicating a downward trajectory. A 10% increase in public investment reduces the CO_2/GDP ratio by approximately 2.67% over a three-year horizon.

Figure 1. Accumulated response of the CO_2/GDP ratio to a public investment shock



Source: Authors' elaboration. The light and dark grey areas represent a 90% confidence interval (1.645 standard deviations) and a 68% confidence interval (1 standard deviation), respectively.

Meanwhile, as shown in Figure 2, the cumulative response of the CO_2/GDP ratio to a shock that increases income inequality follows an upward trajectory over time, with the coefficient statistically significant at the 5% level in the fourth year and at the 10% level in the fifth year. These results suggest that higher levels of income inequality are associated with increases in the carbon intensity of economic activity, consistent with findings in Ogede et al. (2023) and Lamperti et al.(2025), whereas public investment policies appear to contribute to its reduction, as reported by Halkos and Paizanos (2016), Abbass et al. (2021), and Fernandez et al. (2024).

Figure 2. Accumulated response of the CO_2/GDP ratio to a Gini index shock

Source: Authors' elaboration. The light and dark grey areas represent a 90% confidence interval (1.645 standard deviations) and a 68% confidence interval (1 standard deviation), respectively.

The presence of effects in opposing directions among the variables suggests that the impact of public investment on emissions may vary over time and across different socioeconomic contexts. In this light, it becomes relevant to examine potential nonlinearities conditioned on the level of income inequality, as the distributive environment may act as a structural modifier of the effectiveness of decarbonization policies (Fernandez et al., 2024).

In this context, a nonlinear extension of the Local Projections model is employed to examine whether the effects of public investment shocks on carbon emissions systematically differ across regimes of relatively high and low income inequality. This approach aligns with recent findings in the literature that emphasize the role of contextual heterogeneity in shaping the relationship between income inequality and carbon emissions (Grunewald et al., 2017; Mittmann and Mattos, 2020; Lamperti et al., 2025).

4.2 Nonlinear Local Projections

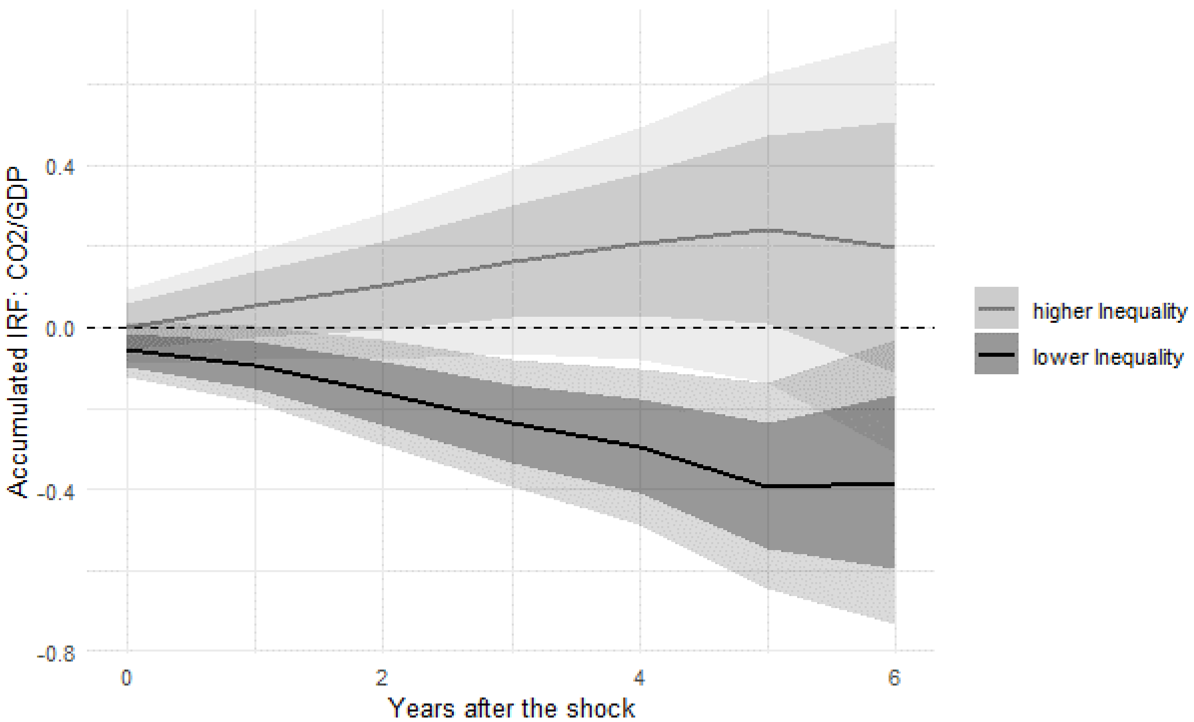
The results from the Nonlinear Local Projections model, shown in Figure 3, indicate that the cumulative response of the CO_2/GDP ratio to a public investment shock in a lower-inequality context features coefficients that are statistically significant at the 10% level from the second to the fifth year. Furthermore, in these lower-inequality settings, a 10% increase in public investment is associated with an approximate 4.40% reduction in carbon intensity (measured by the CO_2/GDP ratio) by the fourth period. By contrast, no statistically significant effect is observed in higher-inequality contexts. The threshold used to distinguish between higher and lower income inequality was a Gini coefficient of 0.4276, classifying 21.15% of the sample as lower income inequality and 78.85% as higher income inequality. This finding suggests that, for the group of Latin American countries analyzed, the environmental effectiveness of public investment depends on the income distribution within these economies.

This pattern appears linked to the role of consumption in macroeconomic dynamics. Higher levels of income inequality not only reduce the marginal propensity to consume but also influence consumption patterns in ways that increase carbon intensity. This is because the consumption habits of the wealthiest segments are typically associated with significantly larger carbon footprints than those of poorer segments.

Consequently, in contexts of higher income concentration, demand stimulus may lead to even more carbon-intensive trajectories, as suggested by the findings in Mittmann and Mattos (2020), Huwe and Rehm (2022), Ogede et al. (2023), and Fernandez et al. (2024).

Thus, in periods characterized by higher income inequality, public investment may not produce the desired environmental outcomes, as income concentration among higher-income groups not only constrains the aggregate demand channel (Carvalho and Rezai, 2016; Sanches et al., 2025) but also directs consumption toward goods and services with higher carbon intensity. The empirical results obtained here therefore reinforce the hypothesis that the effectiveness of fiscal policies—and the very possibility of inducing less carbon-intensive growth trajectories—critically depends on the distributive context (Oswald et al., 2020; Theine et al., 2022; Huwe and Rehm, 2022).

Figure 3. Accumulated response of the CO_2/GDP ratio to a public investment shock at higher and lower income inequality



Source: Authors' elaboration. The light and dark grey areas represent a 90% confidence interval (1.645 standard deviations) and a 68% confidence interval (1 standard deviation), respectively.

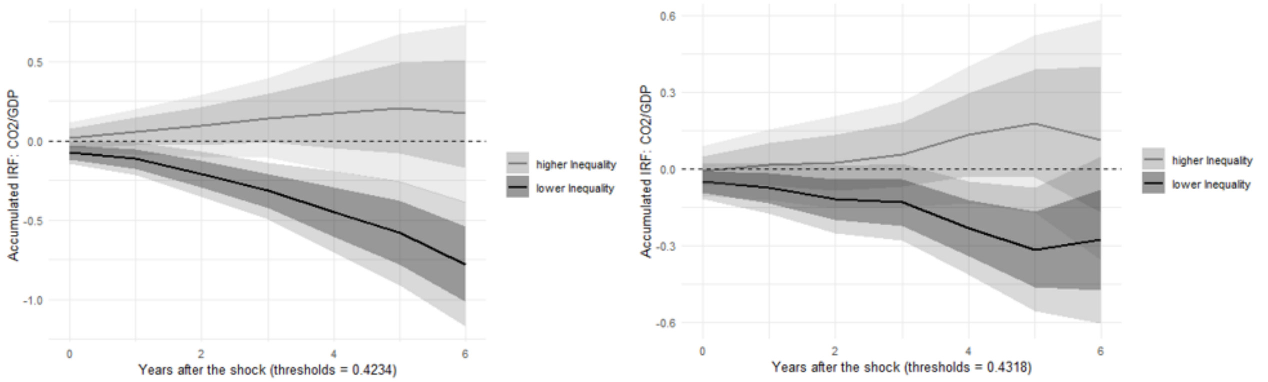
4.3 Robustness check

In this subsection, robustness tests are performed to evaluate the sensitivity of the results to the definition of income inequality regimes. Figure 4 indicates that the effects estimated in the previous subsection remain consistent, even when the threshold used to classify higher and lower income inequality regimes is varied.

To this end, a minimum number of observations per regime was established to ensure sufficiently representative samples and to prevent distortions in the results. In the first test, a minimum of 75 observations was set, yielding a Gini threshold of 0.4234. As a result, 18.27% of the observations were classified under the lower income inequality regime, while 81.73% fell under the higher regime. The minimum was then increased to 100 observations, raising the threshold to 0.4318 and increasing the share of observations in the lower income inequality regime to 24.27%, with the remaining 75.73% in the higher regime. These adjustments confirm the robustness of the results across different classification criteria for income inequality regimes.

The results indicate that the negative effect of public investment on emissions (measured by the CO_2/GDP ratio) becomes more pronounced and persistent when a more restrictive threshold is —that is, when the lower income inequality regime includes only observations with relatively low levels of income inequality. This finding reinforces the evidence that lower income inequality contexts amplify the positive environmental effects of public investment.

Figure 4. Accumulated response of the CO_2/GDP ratio to a public investment shock at higher and lower income inequality with different thresholds



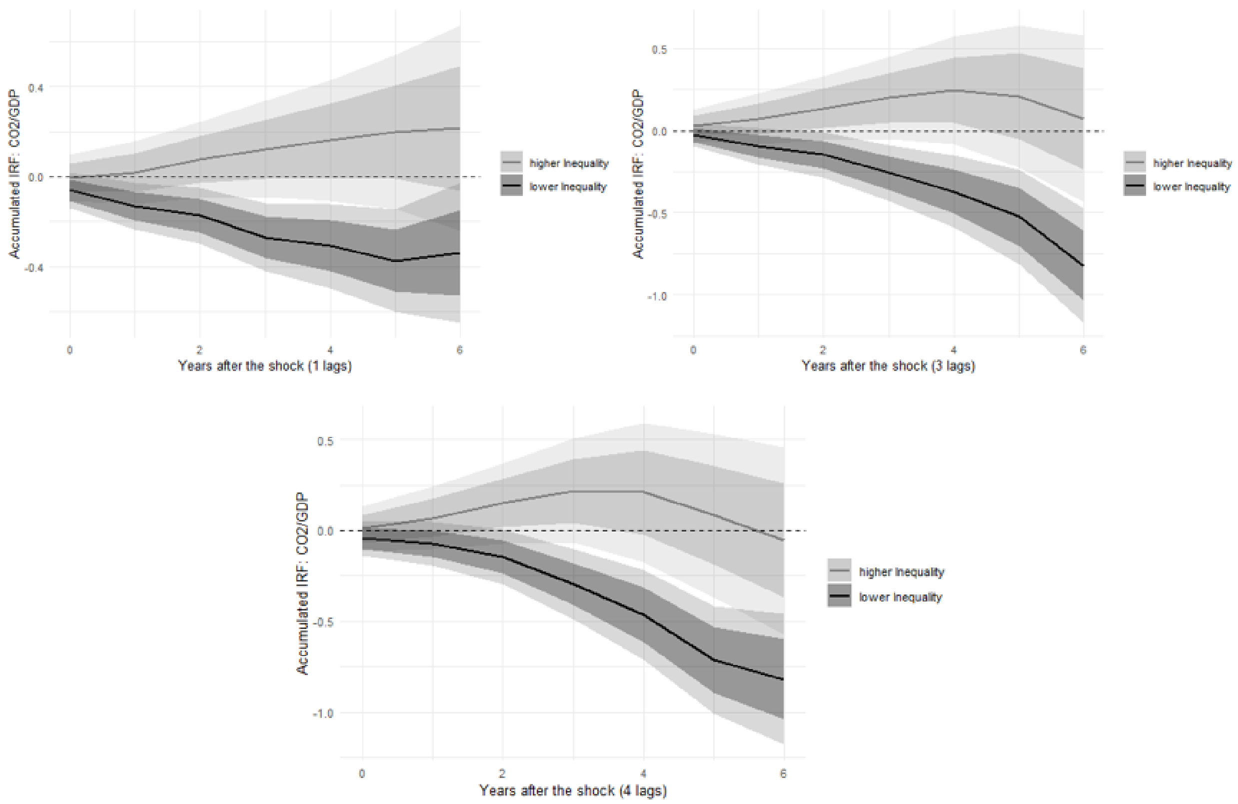
Source: Authors' elaboration. The light and dark grey areas represent a 90% confidence interval (1.645 standard deviations) and a 68% confidence interval (1 standard deviation), respectively.

In a second stage, additional tests were conducted by varying the number of lags in the model (lags = 1, 3, and 4). The results, shown in Figure 5, remained consistent across specifications: public investment is negatively associated with carbon intensity under the lower income inequality regime, while this relationship is weak or absent under higher inequality conditions. Moreover, the negative effect on the CO_2/GDP ratio becomes more pronounced and persistent as the number of lags increases. With one lag, the negative impact is observable up to the fourth year after the shock. When three or four lags are included, the effect intensifies and remains statistically significant for at least six years within the lower income inequality regime. This suggests that public investment yields stronger long-term environmental benefits when the model accounts for the series' past dynamics.

Subsequently, the model was re-estimated with the inclusion of control variables to better isolate the effects of public investment and income inequality on the CO_2/GDP ratio. The results, shown in Figure 6, indicated that the exchange rate, economic growth, inflation, and participation of renewable energy sources exert statistically significant effects. These findings suggest that exchange rate fluctuations may influence the cost of technologies and imported goods (Abbass, 2022; Arbolino et al., 2018); that the pace of economic activity affects energy demand and emissions (Mittmann and Mattos, 2020; Grunewald et al., 2017); and that inflationary pressures can alter consumption and investment behavior (Huwe and Rehm, 2022). Importantly, the inclusion of GDP growth as a control variable ensures that the estimated reduction in the CO_2/GDP ratio following increases in public investment is not merely capturing the effect of economic expansion, but rather captures the independent and substantive contribution of public investment to emissions reduction.

Although the contribution of renewable sources to total energy supply is statistically significant only in the short term, the estimated effect is negative and significant, indicating that increases in renewable energy supply contribute to reductions in CO_2/GDP emissions. In subsequent years, this effect becomes statistically insignificant, suggesting that the impact of renewable energy is concentrated in the immediate horizon and shaped by the broader socioeconomic context. Notably, the inclusion of this control variable

Figure 5. Accumulated response of the CO_2/GDP ratio to a public investment shock at higher and lower income inequality with 1, 3 and 4 lags



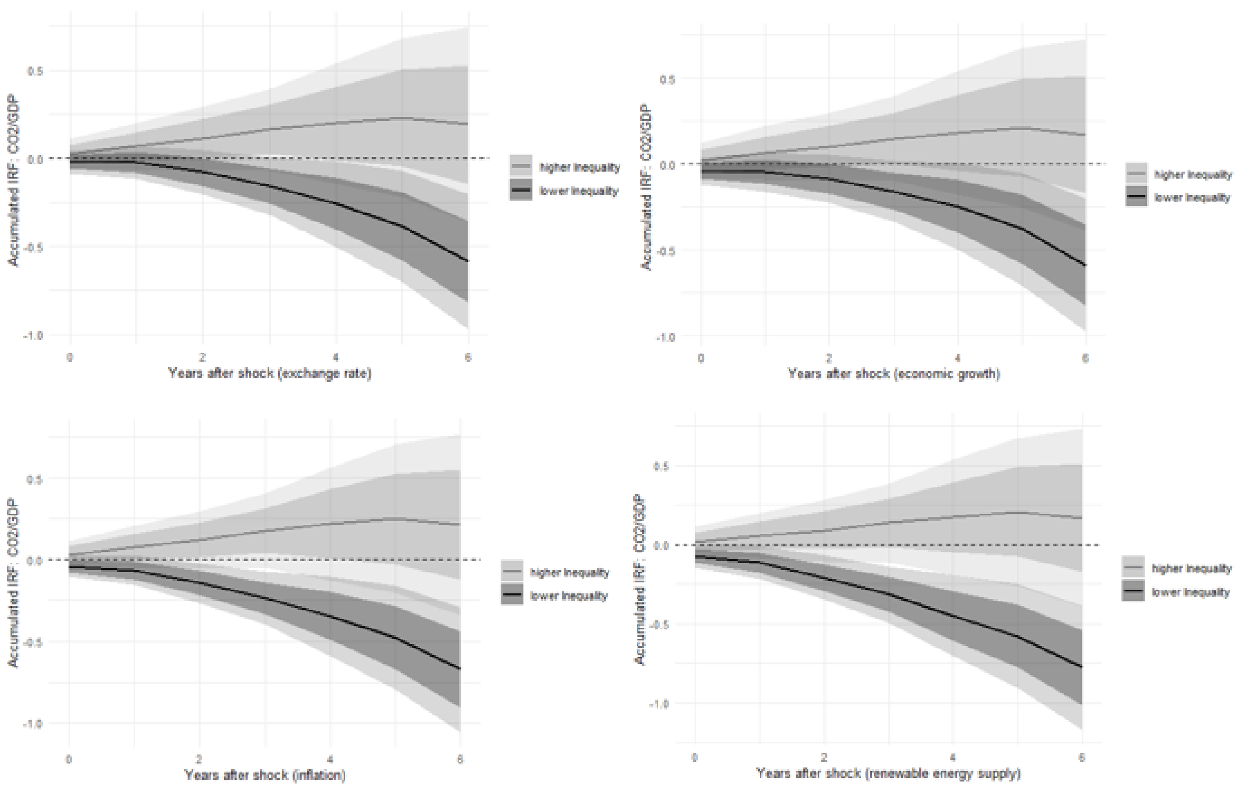
Source: Authors' elaboration. The light and dark grey areas represent a 90% confidence interval (1.645 standard deviations) and a 68% confidence interval (1 standard deviation), respectively.

does not alter the main results, thereby reinforcing the robustness of the effect of public investment on carbon intensity, particularly under conditions of relatively low income inequality.

In contrast, the tests involving the share of industry in GDP, and commodity prices did not yield statistically significant effects. These results align with the literature, which emphasizes the dominant role of structural and technological factors in shaping emissions trajectories (Fernandez et al., 2024; Stern, 2018).

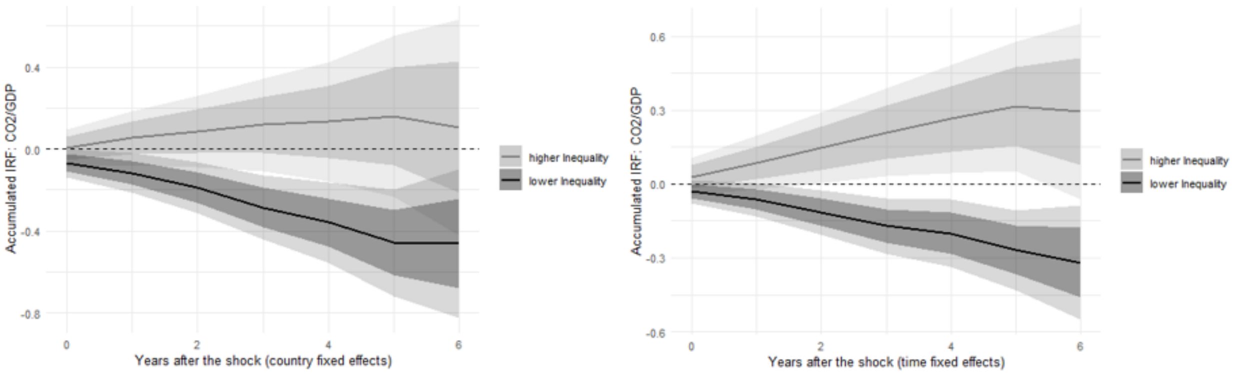
Finally, tests were conducted using fixed effects for country only and year only. The results, shown in Figure 7, remained consistent, further reinforcing the robustness of the original model.

Figure 6. Accumulated response of the CO_2/GDP ratio to a public investment shock at higher and lower income inequality, including control variables: exchange rate, economic growth, inflation, and renewable energy supply



Source: Authors' elaboration. The light and dark grey areas represent a 90% confidence interval (1.645 standard deviations) and a 68% confidence interval (1 standard deviation), respectively.

Figure 7. Accumulated response of the CO_2/GDP ratio to a public investment shock at relatively high and low income inequality with fixed effects for country and years



Source: Authors' elaboration. The light and dark grey areas represent a 90% confidence interval (1.645 standard deviations) and a 68% confidence interval (1 standard deviation), respectively.

5 Discussion

The findings of this study suggest that in Latin American countries, the negative impact of public investment on emissions is more pronounced in contexts with relatively lower income inequality. In other words, policies that advance social justice in tandem with environmental measures appear to strengthen the effectiveness of emissions reduction. One possible reason for this outcome relates to consumption patterns: wealthier individuals tend to have both absolutely and relatively more emission-intensive lifestyles (Theine et al., 2022; Oswald et al., 2021; Huwe and Rehm, 2022). On the other hand, low-income groups emit significantly less, both in absolute and per capita terms, due to their more limited consumption and lower participation in high-environmental-impact activities (Mittmann and Mattos, 2020; Fernandez et al., 2024). For example, in 2019, the richest 10% of the global population were responsible for nearly half of all emissions—driven by both private consumption and investment—while the poorest 50% contributed only about one-tenth (Schöngart et al., 2025).

Moreover, income concentration not only increases individual resource and energy consumption among the wealthiest but also heightens their indirect influence on the climate crisis. Economic elites tend to shape broader consumption norms—often promoting unsustainable patterns—which, in turn, steer society toward high-emission lifestyles. In addition, as key actors or financiers within influential sectors of the fossil fuel economy, they possess political and economic power that can obstruct or delay the adoption of effective climate policies. This creates a vicious cycle in which rising income inequality reinforces elite power, thereby maintaining structural barriers to ecological transition. These dynamics highlight the need for policies that not only reduce income inequality but also curb the excessive concentration of wealth—both of which are crucial for mitigating environmental harm (Nielsen et al., 2021; Huwe and Rehm, 2022).

Therefore, the findings of this study support the case for integrating climate mitigation strategies with income and wealth redistribution to improve their overall effectiveness (Mittmann and Mattos, 2020; Huwe and Rehm, 2022; Ogede et al., 2023; Fernandez et al., 2024). In regions marked by persistent income inequality—such as Latin America—policy agendas must merge social justice with ecological transition as a core response to the climate crisis (Mittmann and Mattos, 2020). By underscoring the influence of income inequality on the environmental outcomes of public investment, this study demonstrates that public sector-led investment, in addition to encouraging private investment (Sanches et al., 2025), can also fulfill crucial social and environmental roles.

6 Concluding remarks

This study aimed to contribute to the literature on public investment, income inequality, and emissions. We found that a 10% increase in public investment leads to an approximate 4.40% reduction in the CO_2/GDP ratio in contexts with relatively lower income inequality, as measured by the Gini index. These results align with existing research suggesting that reductions in income inequality can also contribute to lower emissions (Baek and Gweisah, 2013; Grunewald et al., 2017; Mittmann and Mattos, 2020; Yang et al., 2022; Ogede et al., 2023; Fernandez et al., 2024; Lamperti et al., 2025). Additionally, this paper offers a novel contribution by showing that the emissions-reducing effect of public investment is conditional on the level of income inequality, becoming significantly negative only in less unequal contexts.

This evidence highlights the importance of coordinated public policies that support a just low-carbon transition. Reducing income inequality enhances the effectiveness of public investment—not only by stimulating aggregate demand but also by strengthening the environmental impact of climate policies (Fernandez et al., 2024). In countries with persistently high income inequality, such as many in Latin America, decarbonization efforts cannot be separated from broader social policy objectives. This points to the need for integrated policy agendas that combine redistributive measures with investments in green infrastructure, renewable energy, and low-carbon technologies.

From a policy perspective, the results found in this paper strengthen the argument that fiscal instruments and public investment strategies should be designed with careful consideration of their distributive impacts. By promoting less unequal income and wealth distribution, governments can foster socioeconomic conditions that enhance the environmental effectiveness of public spending. This study aligns with the 17 Sustainable Development Goals (SDGs) adopted by the United Nations in 2015 under the Paris Agreement. Moreover, it suggests that income inequality should be recognized as a fundamental structural barrier to effective climate action.

Finally, it is important to recall that the macroeconomic impact of public investment operates through multiple channels. By increasing aggregate demand, public spending stimulates production, employment, and private consumption, thereby generating a measurable multiplier effect on the economy (Baek and Gweisah, 2013; Sanches et al., 2025). Moreover, public investment can induce a crowding-in effect, encouraging private investment in strategic sectors, including low-carbon technologies, thus amplifying desirable economic and environmental outcomes (Mittmann and Mattos, 2020; Fernandez et al., 2024). Reductions in income inequality further enhance these effects by increasing the marginal propensity to consume among lower-income groups, thereby strengthening the overall impact of public expenditure (Grunewald et al., 2017; Huwe and Rehm, 2022). The central contribution of this study is to incorporate an environmental dimension into these dynamics, demonstrating that public investment not only fosters economic growth and income equity but also effectively reduces CO_2 emissions in contexts of lower income inequality. This highlights the crucial importance of integrating macroeconomic, income redistribution, and environmental policies into a cohesive strategy for achieving sustainable development.

References

Abbass, K.; Song, H.; Khan, F.; Begum, H.; Asif, M. (2021). Fresh insight through the VAR approach to investigate the effects of fiscal policy on environmental pollution in Pakistan. *Environmental Science and Pollution Research*, v.29, 23001-23014.

Ali, A.H. (2023). Green AI for sustainability: leveraging machine learning to drive a circular economy. *Babylonian Journal of Artificial Intelligence*, 15–16.

Arbolino R; Carlucci F; De Simone L; Ioppolo G; Yigitcanlar, T. (2018). The policy diffusion of environmental performance in the European countries. *Ecological Indicators*, v.89, 130-138.

Baek, J.; Gweisah, G. (2013). Does income inequality harm the environment?: Empirical evidence from the United States. *Energy Policy*, v.62, 1434-1437.

Baloch, M.A.; Danish; Ud-Din Khan, S.; Ulucak, S. Z. (2020). Poverty and vulnerability of environmental degradation in Sub-Saharan African countries: what causes what? *Structural Change and Economic Dynamics*, v.54, 143–149.

Bergstrom, K. A. (2020). The role of inequality for poverty reduction. Policy Research Working Paper No. 9409, World Bank.

Brenck, C. (2021). Wage inequality and employment composition in Brazil: a VEC estimation for the period 2004-2019. *Nova Economia*, v.31, 345-380.

Brueckner, M.; Lederman, D. (2018). Inequality and economic growth: the role of initial income. *Journal of Economic Growth*, v.23, 341–366.

Carvalho, L.; Rezai, A. (2016). Personal income inequality and aggregate demand. *Cambridge Journal of Economics*, v.40, 491–505.

Chancel, L.; Bothe, P.; Voituriez, T. (2023). Climate Inequality Report 2023. *World Inequality Lab Study*.

Dollar, D.; Kraay, A. (2002). Growth is good for the poor. *Journal of Economic Growth*, v.7, 195–225.

Dorband, I.I., Jakob, M., Kalkuhl, M., Steckel, J.C. (2019). Poverty and distributional effects of carbon pricing in low- and middle-income countries – A global comparative analysis. *World Development*, v.115, 246–257.

Ederer, S., Rehm, M. (2020). Will wealth become more concentrated in Europe? Evidence from a calibrated post-Keynesian model. *Cambridge Journal of Economics*, v.44, 55–72.

Fernandez, J. A. F.; Cano, M. Á. C.; Quiroga, S. (2024). The interplay between carbon emissions and inequality: a complex networks approach. *Environmental and Sustainability Indicators*, v.24, 100520.

Fisher, J.D.; Johnson, D.S.; Smeeding, T.M.; Thompson, J.P. (2020). Estimating the marginal propensity to consume using the distributions of income, consumption, and wealth. *Journal of Macroeconomics*, v.65, 103218.

Godfrey, L.; Yamagata, T. (2011) A note on a robust test for error cross-section correlation in panel data models. *Manuscript*, University of York.

Grunewald, N.; Klasen, S.; Martínez-Zarzoso, I.; Muris, C. (2017). The trade-off between income inequality and carbon dioxide emissions. *Ecological Economics*, v.142, 249-256.

Grossman, G. M.; Krueger, A. B. (1995). Economic growth and the environment. *The Quarterly Journal of Economics*, v.110, 353–377.

Halunga, A. G.; Orme, C. D.; Yamagata, T. (2016). A heteroskedasticity robust Breusch–Pagan test for Contemporaneous correlation in dynamic panel data models. *Journal of Econometrics*, v.198, 209-230.

Halkos, G. E.; Paizanos, E. A. (2016). The effects of fiscal policy on CO_2 emissions: Evidence from the USA. *Energy Policy*, v.88, 317-328.

Hartley, J. S.; Mejia, J. (2025). *Smooth panel local projections*. Manuscript (SSRN).

Hinkley, D. V. (1977). Jackknifing in Unbalanced Situations. *Technometrics*, v.19, 285–292.

Huwe, V.; Rehm, M. (2022). The ecological crisis and post-Keynesian economics – bridging the gap? *European Journal of Economics and Economic Policies: Intervention*, v. 19, 397-414.

International Monetary Fund (IMF). (2024). G-20 background note on the impact of growth on inequality and social outcomes. Available at:<link> Accessed on: July 01, 2025.

Jochmans, K. (2020). Heteroscedasticity-Robust inference in linear regression models with many covariates. *Journal of the American Statistical Association*, v.117, 887-896.

Jordà, O. (2005). Estimation and inference of impulse responses by local projections. *American Economic Review*, v.95, 161–182.

Jorgenson, A.; Schor, J.; Huang, X. (2016). Income inequality and carbon emissions in the United States: a state-level analysis, 1997–2012. *Ecological Economics*, v.134, 40-48.

Kaika, D.; Zervas, E. (2013). The Environmental Kuznets Curve (EKC) theory—Part A: concept, causes and the CO_2 emissions case. *Energy Policy*, v.62, 1392–1402.

Lamperti, F.; Palagu, E.; Perniola, T. (2025). *The emission-inequality nexus across stages of development*. Working Paper Series. Laboratory of Economics and Management (LEM).

Mittmann, Z.; Mattos, E. J. (2020). Income inequality and carbon dioxide emissions: evidence from Latin America. *Journal of International Development*. v.32, 389–407.

Morena, E.; Krause, D.; Stevis, D. (2020). *Just transitions: Social justice in the shift towards a low-carbon world*. Pluto Press.

Nielsen, K.S., Nicholas, K.A., Creutzig, F., Dietz, T., Stern, P. C. (2021). The role of high socioeconomic-status people in locking in or rapidly reducing energy-driven greenhouse gas emissions. *Nature Energy*, v.6, 1011–1016.

Ogede, J. S.; Oduola, M. O.; Tiamiyu, H. O. (2023). Income inequality and carbon dioxide (CO_2) in sub-Saharan Africa countries: the moderating role of financial inclusion and institutional quality. *Environment, Development and Sustainability*, v.26, 18385-17409.

Oswald, Y.; Owen, A.; Steinberger, J.K. (2020). Large inequality in international and intranational energy footprints between income groups and across consumption categories. *Nature Energy*, v.5, 231–239.

Oswald, Y., Steinberger, J.K., Ivanova, D., Millward-Hopkins, J. (2021). Global redistribution of income and household energy footprints: a computational thought experiment. *Global Sustainability*, v.4, 1–13.

Rodrigues, L. H. G.; Gomes, J. P. de F.; Marques, P. R. (2025). A desigualdade nas emissões de carbono entre as famílias brasileiras. Nota de Política Econômica (NPE) n° 76, Centro de pesquisa em macroeconomia das desigualdades (Made-USP).

Sanches, M.; Taioka, T.; Benck, C. Z.; Serra, G. P. (2025). How does income distribution affect the impact of public investment on private investment? Empirical evidence from Brazil. *EconomiA*, v. 26, 193–207.

Scruggs, L.A. (1998). Political and economic inequality and the environment. *Ecological Economics*, v. 26, 259–275.

Schöngart, S; Nicholls, Z.; Hoffmann, R.; Pelz, S.; Schleussner, C. F. (2025). High-income groups disproportionately contribute to climate extremes worldwide. *Nature Climate Change*, v.15, 627-633.

Semykina, A.; Wooldridge, J.M. (2010). Estimating panel data models in the presence of endogeneity and selection. *Journal of Econometrics*, v.157, 375–380.

Solt, F. (2020). Measuring income inequality across countries and over time: the standardized world income inequality database. *Social Science Quarterly*, v.101, 1183–1199.

Stern, D.I. (2018). The environmental Kuznets Curve. Available at:<link> Accessed on: September 01, 2025.

Taioka, T; Terra, F. H. B. (2024). An empirical analysis of the relationship between real wage appreciation and inflation in Brazil. *Journal of Post Keynesian Economics*, v.48., 103-123.

Theine, H., Humer, S., Moser, M., Schnetzer, M. (2022). Emissions inequality: disparities in income, expenditure, and the carbon footprint in Austria. *Ecological Economics*, v. 197, 107435.

Yang, Z.; Ren, J.; Ma, S.; Chen, X.; Cui, S.; Xiang, L. (2022). The emission-inequality nexus: empirical evidence from a wavelet-based quantile-on-quantile regression approach. *Frontiers in Environmental Science*, v.10.

Ye, Z.; Zhu, Y.; Ji, X.; Meng, J. (2023). The triplet link of carbon emission, economic development, and income inequality: a global panel model perspective. Available at:<link> Accessed on: September 01, 2025.

Zhang, C.; Zhao, W. (2014). Panel Estimation for Income Inequality and CO2 Emissions: A Regional Analysis in China. *Applied Energy*, v.136, 382-392.

Appendix A – Model Specification

A series of statistical tests supported the choice of the fixed effects model. Initially, the F-test for individual (country) and temporal effects was performed, rejecting the null hypothesis of no fixed effects with p-values below 0.01, indicating the relevance of these effects in the data structure. Additionally, the F-test for two-way effects—simultaneously accounting for fixed effects by country and year—also rejected the null hypothesis, reinforcing the need to control for both dimensions. The Hausman test was then applied to choose between fixed and random effects models (Abbass et al., 2021; Grunewald et al., 2017). The results indicated that the fixed effects model is consistent and preferable, as it rejected the null hypothesis of estimator equivalence with highly significant p-values.

Complementary diagnostic tests were conducted to assess the quality of the model and the robustness of the results. To test for serial autocorrelation in the residuals, the Wooldridge panel test was applied, indicating no significant autocorrelation (Semykina and Wooldridge, 2010). Regarding heteroskedasticity, the Breusch-Pagan test (Godfrey and Yamagata, 2011; Halunga et al., 2017) detected its presence, leading to the use of the HC1 robust standard error estimator (heteroskedasticity-consistent covariance matrix estimator, type 1) (Hinkley, 1977; Jochmans, 2020). This correction adjusts the variance–covariance matrix of the coefficients, ensuring valid and reliable inferences even in the presence of heteroskedasticity.

Additionally, we tested the normality of the residuals using the Shapiro-Wilk test, which indicated a deviation from normality. However, given the large sample size and the robustness of the estimators when using robust standard errors, the inference remains valid. Achieving normality in short-term time series is often challenging. According to the Law of Large Numbers, as the sample size increases, the sample mean converges to the population mean, leading the error term to approximate a normal distribution (Taioka and Terra, 2024; Brenck, 2021; Sanches et al., 2025).