Income inequality as a barrier to the CO_2-reducing impact of public investment: evidence from Latin America

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Resumo

Este artigo tem como objetivo analisar empiricamente o impacto do investimento público sobre as emissões de carbono em relação ao Produto Interno Bruto (PIB) para um painel de países latino-americanos no período de 1994 a 2019. Considerando que a redução da desigualdade de renda pode aumentar a eficácia das políticas ambientais, as estimações são realizadas sob dois regimes de desigualdade de renda: maior e menor. Emprega-se um modelo não linear de Projeções Locais com limiar (*threshold*), dividindo a amostra em dois grupos com base no índice de Gini. Os resultados mostram que, durante períodos de desigualdade de renda relativamente baixa, a resposta estimada do crescimento da intensidade de carbono a um choque de investimento público é negativa ao longo do tempo. Em contraste, sob condições de desigualdade de renda relativamente alta, o efeito não é estatisticamente significativo ao nível de 10%. Nossas estimativas sugerem que um choque de 10% no investimento público está associado a uma redução aproximada de 4,40% na taxa de crescimento da intensidade de carbono no regime de baixa desigualdade, mensurada pelo índice de Gini, até o quarto ano após o choque. Esses achados empíricos corroboram a literatura existente que destaca a associação positiva entre desigualdade de renda e emissões de carbono.

Palavras-chave: crescimento da intensidade de carbono; investimento público; desigualdade de renda; países latino-americanos.

Abstract

This paper aims to empirically analyze the impact of public investment on carbon emissions relative to Gross Domestic Product (GDP) for a panel of Latin American countries from 1994 to 2019. Given that reduced income inequality can enhance the effectiveness of environmental policies, the estimations are carried out under two income inequality regimes: higher and lower. A nonlinear Local Projections model with a threshold is employed, dividing the sample into two groups based on the Gini index. The results show that during periods of relatively low income inequality, the estimated response of carbon intensity growth to a public investment shock is negative over time. In contrast, under conditions of relatively high income inequality, the effect is not statistically significant at the 10% level. Our estimates suggest that a 10% shock to public investment corresponds to an approximately 4.40% reduction in the growth rate of carbon intensity in the low-inequality regime, as measured by the Gini index, until the fourth year after the shock. These empirical findings support existing literature highlighting the positive association between income inequality and carbon emissions.

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

JEL Classification: C33; E22; O54; Q52.
Área 2. Distribuição de Renda, Conflito Social e Crescimento Econômico

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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.

Several empirical studies have examined the relationship between income inequality and environmental outcomes, though their conclusions remain mixed. While some studies find that reductions in income inequality may increase emissions through higher consumption among lower-income groups (Fisher et al., 2020; Stern, 2018), others suggest that more equal societies tend to achieve better environmental outcomes (Baek and Gweisah, 2013; Zhang and Zhao, 2014).

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, the 29th Conference of the Parties to the United Nations Framework Convention on Climate Change, held in Baku in 2024, reaffirmed the principle of a just transition as a cornerstone of international climate policy. COP30, held in Brazil in 2025, aimed 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).

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. 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.[4] 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).

Recent advances in climate-economy modeling emphasize that the economic impacts of climate change and the effectiveness of mitigation and adaptation policies are highly heterogeneous across space and institutional contexts, predicting substantial increases in spatial inequality (Desmet and Rossi-Hansberg, 2026). Spatial integrated assessment models show that climate damages and adaptation responses vary substantially across regions due to differences in geography, economic structure, and mobility frictions (Conte et al., 2021; Desmet et al., 2021; Cruz and Rossi-Hansberg, 2024). Related research also shows that the macroeconomic impacts of low-carbon transitions depend on countries' structural characteristics and policy frameworks, particularly in developing regions such as Latin America (Magacho et al., 2026). Recent model-based assessments further indicate that climate impacts themselves may increase income inequality unless mitigation policies are accompanied by redistributive mechanisms (Emmerling et al., 2024). This growing literature highlights the importance of structural conditions in shaping environmental outcomes.

Complementing this perspective, studies combining economic data on wealth distribution with climate models of extreme events demonstrate how social and economic structures amplify environmental impacts. For instance, Schöngart et al. (2025) highlight how social and economic structures shape environmental outcomes, offering a broader perspective for understanding the intersection of inequality, policy, and climate risk. The main finding is that the wealthiest 10% of the population are responsible for two-thirds of global warming and contribute disproportionately to extreme climate events.

Recent empirical studies also document complex and context-dependent relationships between income inequality and CO_2 emissions across countries, reflecting differences in consumption patterns, economic structures, and energy systems (Dorn et al., 2024). Moreover, climate impacts themselves tend to be unevenly distributed across regions and populations, often disproportionately affecting vulnerable groups in developing countries (Paglialunga et al., 2022; Ngcamu, 2023).

These findings suggest that socioeconomic structures, including income distribution and wealth concentration, can condition the effectiveness of public policy interventions, highlighting the relevance of integrating social and environmental perspectives in development research. In this

[4] 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).

context, the study carried out in this paper 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; Cappelli, 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 equality and environmental sustainability. Second, it employs a method that accounts for nonlinearities and regional heterogeneity (controlling for country fixed effects), thereby enabling and contributing to more robust and context-specific policy recommendations for countries seeking to simultaneously reduce both emissions and income inequality.

The results indicate that public investment is associated with reductions in the growth rate of carbon intensity in contexts of relatively lower income inequality, whereas its impact is not statistically significant in higher-inequality settings at the 10% level of significance. Specifically, a 10% increase in public investment corresponds to an estimated 4.40% decrease in the growth of carbon intensity, as measured by the CO_2/GDP ratio, after the fourth period in lower-inequality contexts. These effects are statistically significant at the 5% level between periods 1 and 6 after the shock. Overall, 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. Existing 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).

More recent studies extend this evidence to broader fiscal interventions. Bordenave and Ciaffi (2025) show that green public spending increases GDP and employment while crowding in private investment, with heterogeneous effects across countries depending on income levels. Di Bucchianico et al. (2025) find that the impact of government spending on emissions depends on the type of expenditure and the structural characteristics of the economy. Das et al. (2026) highlight that changes in top-income shares are positively linked to CO_2 emissions in Canada. Cassin et al. (2025) indicate that higher income inequality is associated with lower public environmental expenditure, reflecting substitution effects between public environmental spending and private green consumption. In a related perspective, Cappelli (2025) shows that different income groups contribute unevenly to consumption-based emissions, with increases in the income share of the top deciles associated with higher per-capita emissions, while the contribution of poorer groups is negligible.

Alongside the fiscal policy literature, a parallel strand of research investigates the relationship between income inequality and environmental outcomes. Broadly speaking, two main perspectives can be identified.

The first perspective 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.

Taken together, these contrasting perspectives indicate that the relationship between income inequality and environmental outcomes is not theoretically unambiguous. Empirical evidence

generally suggests that lower income inequality tends to be associated with reductions in carbon emissions, while higher income inequality may 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) indicate that, while lower-income groups emit less in absolute terms, their consumption is relatively more carbon-intensive per unit of income. Typical examples include inexpensive processed foods, older and inefficient fossil fuel-powered transportation, and electricity derived from non-renewable sources. In contrast, 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, appliance-intensive housing. Additionally, higher-income groups are responsible for the largest carbon footprints, often exceeding globally sustainable thresholds by several multiples (Huwe and Rehm, 2022). This is consistent with findings by Santos et al. (2026), who show that in Brazil the richest 10% account for a disproportionate share of household emissions, especially from food and transport. Similarly, Ghazouani and Hamdi (2025) demonstrate that income inequality amplifies carbon emissions across OECD countries, although financial technology can help mitigate this effect. 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. (202	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.
Bordenave and Ciaffi (2025)	30 European countries (1995 - 2020)	Linear and Nonlinear Local Projections	Green public spending can boost GDP, employment, and private investment, with heterogeneous effects across countries depending on income levels and the composition of green fiscal expenditures.

Cappelli (2025)	107 countries (1990 – 2019).	Dynamic difference-GMM model and a dynamic threshold regression model	Increases in the income share of the top 10% raise CO_2 emissions at higher income levels, while the middle-income group is associated with lower emissions.
Cassin et al. (2025)	30 European countries (1995 - 2021)	Panel econometric analysis with fixed effects & Driscoll–Kraay errors	Higher income inequality is associated with lower public environmental expenditure. The negative relationship weakens at higher levels of inequality, and there is evidence of substitution between public environmental spending and private green consumption.
Das et al. (2026)	Canada (1981-2021)	Autoregressive distributed lag bounds (cointegration)	Positive long-run cointegrating relationship between changes in the share of income of the top 1% and changes in CO_2 emissions.
Di Bucchianico et al. (2025)	United States (1980-2019)	Bayesian factor-augmented interacted vector autoregression	Evidence suggests that the effects of government spending on emissions depend on the type of expenditure and the broader economic context, highlighting that fiscal policy can either amplify or mitigate carbon intensity depending on structural factors.
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.
Ghazouani and Hamdi (2025)	33 OECD countries (2000-2020)	Various techniques (OLS, panel threshold, instrumental variables)	Income inequality increases carbon emissions, while financial technology mitigates them and weakens the environmental impact of inequality.
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.
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.
Santos et al. (2026)	Brazil (2009-2018)	Input-output analysis	Food and transport are the primary contributors to household carbon emissions. Technological improvements have significantly reduced emissions over time, yet inequality remains high, with the richest 10% responsible for a disproportionately large share of total emissions.

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)[5]. 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).[6] We focus on disposable income inequality because it captures the effective distribution of income after taxes and transfers, which is the dimension most closely related to consumption patterns and investment decisions that may shape carbon emissions.

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

[6] The literature identifies the Standardized World Income Inequality Database as the most systematic effort to address the lack of comparable inequality data for a large number of countries (Berg et al., 2018). For this reason, it has become widely used in macroeconometric studies (Heimberger, 2020; Cardoso and Carvalho, 2023; Agnello and Sousa, 2014). Nevertheless, some criticisms have been raised regarding the dataset, particularly concerning the imputation procedures used in its construction (Jenkins, 2014). Solt (2015), however, argues that the SWIID follows the recommendations proposed in Atkinson and Brandolini (2009) to improve the comparability of inequality measures across heterogeneous sources, rendering it suitable for cross-country empirical analyses.

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.
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.
9. **CO_2 emissions per capita**: measure the average annual carbon dioxide emissions generated per person in a country. The indicator is calculated as total national CO_2 emissions from fossil fuels and industrial processes divided by the population. The data are based on the Global Carbon Budget and compiled by Our World in Data.

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 ∈ {0,1,2,...,6} is specified as follows:

$$y_{i,t+h} = \alpha_i + \lambda_t + \beta_h pub_{i,t} + \gamma_h(pub_{i,t}D_{i,t}) + \delta'_h X_{i,t} + \varepsilon_{i,t+h} \quad (1)$$

where $y_{i,t+h}$ denotes the dependent variable, measured as the CO_2/GDP ratio for country i at horizon t+h; αi are country-specific fixed effects that capture time-invariant heterogeneity across countries, such as institutional characteristics or structural factors; λt 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); pubi,t represents the identified shock to public investment at time t, with its effect under lower income inequality regimes captured by βh; Di,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 γh; Xi,t is a vector of control variables with associated coefficients δh′ , 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 εi,t+h is the error term, capturing unobserved shocks not explained by the model (further methodological details can be found in Appendix A.1).

Panel unit root tests by Levin, Lin, and Chu (LLC), and Im, Pesaran, and Shin (IPS) were applied. All variables were log-transformed prior to estimation. 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 in order to address non-stationarity and avoid potential spurious regressions when working with macroeconomic time series in levels.[7] As a consequence, the estimated responses should be interpreted as effects on changes in the growth rate of carbon intensity rather than on its level. Public investment, by contrast, is specified in levels. Accordingly, cumulative impulse response functions are employed to capture the total impact of public investment on the growth rate of carbon intensity.

To address potential endogeneities and simultaneous determination between public investment, income inequality, and carbon intensity, we include lags of public investment and carbon intensity in the main model. This allows us to capture the persistence of these variables and reduce the risk that estimated responses reflect contemporaneous feedback effects.

To determine the appropriate number of lags for the public investment and carbon intensity variables, 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

[7] Among the control variables, only the exchange rate was found to be non-stationary and was therefore also transformed into first differences.

control variable for public investment and CO_2/GDP in the baseline nonlinear exercise to control the persistence of these variables (Heimberger, 2020).

In the robustness section, we further strengthen the specification by including lags of economic growth as additional control variables, accounting for macroeconomic dynamics that may simultaneously affect fiscal policy and emissions. Moreover, we perform robustness exercises in which the regime classification is based on lagged values of the Gini coefficient, helping to mitigate potential simultaneity between income inequality and fiscal policy decisions. These steps ensure that the estimated dynamic effects of public investment shocks more accurately reflect causal relationships rather than being driven by reverse causality or simultaneous interactions among the key variables.

To further address potential endogeneity concerns, we also measure carbon emissions in per capita terms (CO_2 per capita) in addition to the baseline CO_2/GDP ratio, in the robustness checks section. Using carbon per capita reduces mechanical correlations with country size and GDP fluctuations, allowing for a more comparable assessment of emissions across countries. This approach helps to partially mitigate simultaneity between public investment, economic growth, and emissions, while preserving the dynamic structure captured by our local projection framework.

4. RESULTS

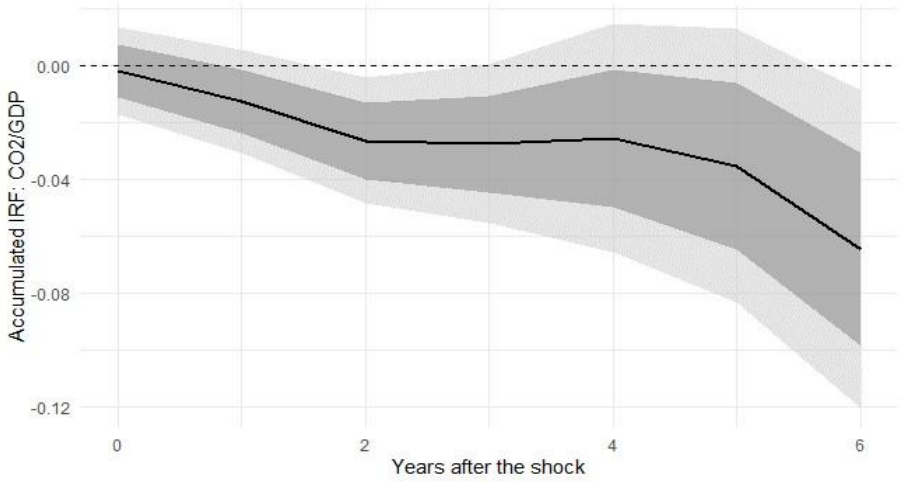
4.1.Linear Local Projections

Before estimating the nonlinear model, preliminary estimations were conducted using the Local Projections approach. Three lags were included based on the optimal lag length indicated by AIC, BIC, and HQIC information criteria, which were calculated from the model residuals across lag lengths ranging from 1 to 4. 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 growth rate of 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 is associated with a cumulative decline in the CO_2/GDP ratio growth rate 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 growth rate of the CO_2/GDP ratio by approximately 2.67% over a three-year horizon.

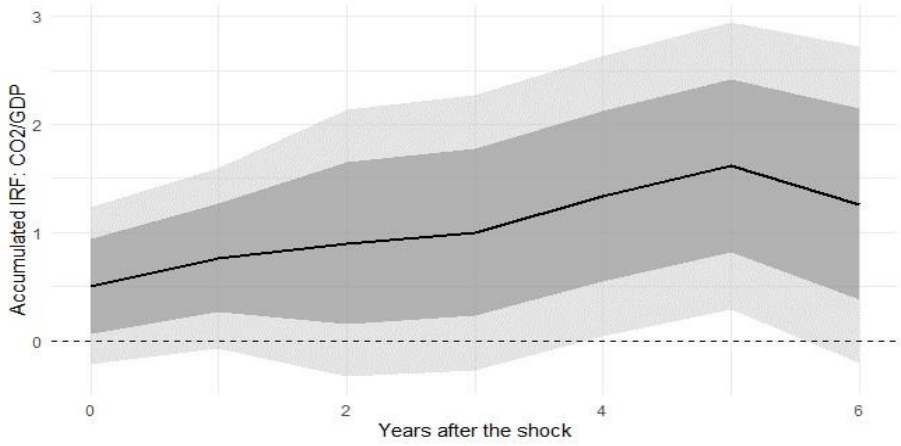
Figure 1. Accumulated response of the CO_2/GDP ratio to a public investment shock



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 cumulative 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 the growth rate of carbon intensity (measured by the CO_2/GDP ratio) by the fourth period. These effects are statistically significant at the 5% level between periods 1 and 6. By contrast, no statistically significant effect at the 10% level of significance is observed in higher-inequality contexts[8]. 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.

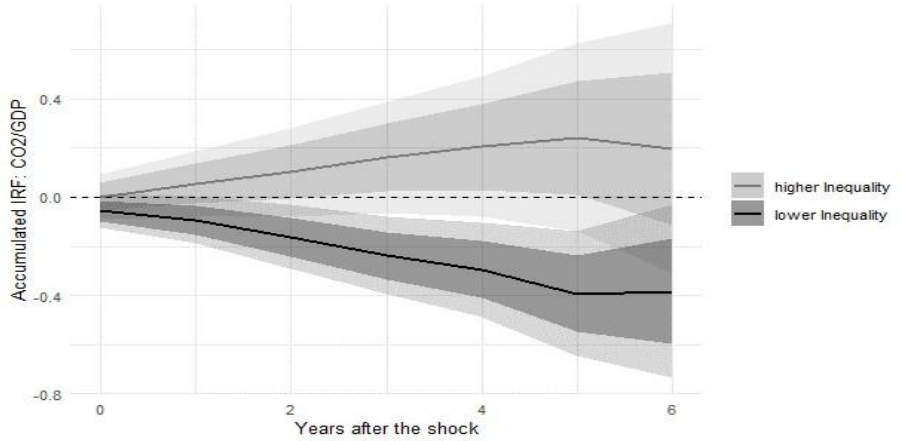
This pattern appears linked to the role of consumption in macroeconomic dynamics. Higher levels of income inequality not only reduce the marginal propensity to consume but also influence consumption patterns in ways that increase carbon intensity. This is because the consumption habits of the wealthiest 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).

[8] Note, however, that the response is positive and statistically significant when we consider the one-standard deviation band in periods three and four after the shock.

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 checks

The robustness analyses described in this subsection were conducted across multiple alternative specifications. The results remained robust and qualitatively consistent with the baseline estimates. Overall, the findings continue to indicate that public investment reduces the growth rate of carbon intensity, particularly in contexts characterized by relatively low levels of income inequality[9].

The exercises included: (i) alternative definitions of income inequality regimes, using different Gini index thresholds and minimum observation requirements, in order to verify whether the results were sensitive to the classification criteria of higher- and lower-inequality regimes; (ii) specifications with different lag structures for public investment and carbon intensity variables, testing whether the estimated effects depended on the model's dynamic structure; (iii) the inclusion of additional macroeconomic and energy-related control variables, such as exchange rates, inflation, GDP growth, renewable energy participation, industrial share, and commodity prices, to isolate the

[9] The robustness tests and corresponding results can be made available upon request.

independent effect of public investment on emissions; (iv) estimations using alternative fixed effects structures (country-only and year-only fixed effects) to assess whether the findings depended on the chosen panel specification; (v) tests employing lagged GDP growth and lagged Gini index values to mitigate potential endogeneity and simultaneity concerns; (vi) the use of CO2 emissions per capita as an alternative dependent variable, verifying whether the results were sensitive to the emissions indicator adopted; and (vii) leave-one-country-out estimations, in which each country was sequentially excluded from the sample to assess whether the results were being driven by any single country. In all cases, the main conclusions of the baseline model were preserved.

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.

We posit that income inequality conditions the effectiveness of public investment on emissions via three interrelated channels: (i) consumption patterns, where high inequality concentrates emission-intensive consumption among a small fraction of the population; (ii) political economy, where economic elites influence policy and sectoral investment allocation, potentially obstructing green investment; and (iii) investment allocation, where inequality shapes which sectors benefit from public investment, influencing the carbon intensity of economic activity. While our empirical strategy does not directly test each channel, this conceptual framework helps interpret the observed heterogeneous effects across inequality regimes.

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; Cappelli, 2025). 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 resources 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.

Overall, this framework clarifies how income inequality can amplify or dampen the environmental impact of public investment. While the specific channels are not empirically tested here, the discussion offers a conceptual basis for understanding the heterogeneous effects observed in our econometric exercise.

6. CONCLUDING REMARKS

This study aimed to contribute to the literature on public investment, income inequality, and emissions. We find that a 10% increase in public investment is associated with an estimated 4.40% reduction in the growth rate of the CO_2/GDP ratio in contexts with relatively lower income inequality, as measured by the Gini index. These effects are statistically significant at the 5% level between periods 1 and 6 after the shock. In contrast, no statistically significant effect at the 10% level is observed in higher-inequality contexts. Our findings indicate that public investment is associated with changes in the carbon intensity growth rate depending on the income inequality regime, but they do not imply that public investment directly affects income inequality.

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.

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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).