AMERICAN UNIVERSITY OF BEIRUT

INCOME INEQUALITY, TRADE, AND ENVIRONMENTAL EXTERNALITIES

by
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Abstract of the Thesis of

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This paper investigates the intersection of income inequality, international trade, and environmental externalities, with a focus on carbon dioxide (CO_2) emissions. Drawing on a panel dataset of 160 countries from 1980 to 2019, the study combines a theoretical framework grounded in welfare economics with empirical analysis using fixed-effects panel regressions. The results reveal that income concentration—particularly among the top 9% and top 1%—is a strong predictor of higher CO_2 emissions. This relationship is intensified in countries that are more open to trade, suggesting that trade may facilitate the offshoring of pollution-intensive production.

We distinguished between production-based and consumption-based emissions and shows that elite income groups not only emit more domestically, but also import significant carbon-intensive goods, effectively externalizing environmental costs to other countries. These dynamics are especially pronounced in advanced economies and high-income countries, while emerging and low-income economies exhibit more localized effects.

By incorporating trade interactions and disaggregated income shares, the analysis offers new evidence on the spatial and social distribution of emissions. The findings underscore the need for climate policies that recognize and address both inter- and intra-national inequalities in emissions responsibility. Redistribution, progressive carbon taxation, and trade reforms may be key levers in achieving both climate and social justice.

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Abbreviations

CO_2	Carbon Dioxide
DINA	Distributional National Accounts
EE-MRIO	Environmentally Extended Multi-Regional Input–Output
EMDEs	Emerging and Developing Economies
EPA	Environmental Protection Agency
GDP	Gross Domestic Product
GHG	Greenhouse Gas
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
MRIO	Multi-Regional Input–Output
OECD	Organisation for Economic Co-operation and Development
PBA	Production-Based Accounting
PPP	Purchasing Power Parity
SNA	System of National Accounts
WDI	World Development Indicators
WID	World Inequality Database
WTO	World Trade Organization

Chapter 1

Introduction

Climate change and carbon emissions are not only environmental challenges but also mirror deep structural inequalities in the global economy. While CO_2 emissions are generated globally, the causes and consequences are unevenly distributed. Rich countries and individuals consume disproportionately more energy and goods, leading to a higher share of global emissions, while poorer populations, particularly in the Global South, face the brunt of climate-related disasters, displacement, and environmental degradation.

Global inequality plays a central role in shaping this imbalance. Through international trade and global production networks, wealthy countries often outsource their pollution to low-income countries, where environmental regulations are weaker, and labor is cheaper. The environmental cost is borne by local communities in the form of degraded ecosystems, public health crises, and lost development opportunities.

1.1 Problem and Intuition

Global inequalities have been rising over the past decades, with significant implications for environmental sustainability. While much attention has been given to how economic development affects carbon emissions, less is known about how income is distributed within countries and how that distribution relates to environmental outcomes. In particular, the relationship between income inequality and CO_2 emissions remains underexplored, especially in the context of increasing globalization and trade openness.

The underlying intuition of this study is that individuals at the top of the income distribution tend to consume more goods and services, many of which are carbon-intensive. However, in countries that are more open to trade, a portion of this consumption is often imported, which can result in the outsourcing of emissions. This suggests that the domestic environmental footprint of the rich may be lower in open economies, even if their overall consumption remains high. Based on this reasoning, I hypothesize that income inequality, particularly the share of income held by the top 1% and top 9%, has a differential effect on CO_2 emissions depending on trade patterns and interactions.

1.1.1 *Externalities and Social Welfare (Pigouvian Perspective)*

Classical welfare economics provides the foundation for understanding environmental externalities. Arthur C. Pigou (1920) introduced the concept of externalities as costs or benefits from an economic activity that affect third parties and are not reflected in market prices. In Pigou's framework, negative externalities (like pollution) create a divergence between private costs and social costs, leading to an overproduction of "bads" from society's perspective. Climate change is a textbook example: emitters of greenhouse gases impose costs on others (through environmental damage and climate risks) that they do not pay for. In the Pigouvian view, this market failure warrants intervention (e.g. taxes or regulations) to internalize the external cost and improve social welfare. Thus, environmental externalities are central to welfare economics, they result in socially suboptimal outcomes where private gains come at the expense of public well-being.

1.1.2 *Inequality in Emissions and the Marginal Propensity to Emit*

Environmental externalities in the climate context are tightly interwoven with global income inequalities. A growing body of research-mainly after Chancel and Piketty et al. in the World Inequality Lab, shows that greenhouse gas emissions are highly skewed by income group: the richest individuals and countries contribute a disproportionate share of emissions. For example, in 2019 the top 10% of the world's population was responsible for about 48% of global CO_2 emissions, while the poorest 50% accounted for only 12%. The global top 1% alone emitted an estimated 15–17% of world CO_2 in 2019, vastly more than the emissions of the majority of humanity (**?**). This unequal distribution of emissions has given rise to the concept of a "polluter elite," a small wealthy segment of the population whose lifestyles and investments drive enormous carbon footprints.

To analyze how income translates into emissions, scholars introduce the idea of a marginal propensity to emit (MPE)—the incremental CO_2 emissions associated with an additional unit of income [1]. This concept is analogous to the marginal propensity to consume, but focuses on carbon intensity of consumption. Evidence suggests that MPE is not uniform across the income spectrum. At lower income levels, basic needs and energy requirements mean that additional income can lead to significant increases in emissions. At very high incomes, the MPE may diminish somewhat. However, even if the richest have a slightly lower MPE at the margin, their absolute level of consumption ensures their total emissions far exceed those of poorer groups. The stark reality remains that a highly unequal income distribution leads to a highly unequal emissions distribution.

1.1.3 *Trade Openness, Global Value Chains, and Emissions Displacement*

Globalization and trade are critical mechanisms linking inequality to environmental externalities. International trade theory provides insight into how opening up trade can change the location and scale of pollution. Greenhouse gas (GHG) emissions are being displaced from developed nations to developing ones through international trade [2], [3]. In a North–South trade model, differences in factor endowments and environmental regulations can cause a composition effect: pollution-intensive industries concentrate where production is cheapest or regulations are lax. This phenomenon, known as the Pollution Haven Hypothesis [4], predicts that developing countries may become havens for dirty industries as trade liberalizes.

Empirical evidence supports the idea that trade enables emissions displacement. [5] estimate that over 5.3 gigatons of CO_2 were embodied in international trade in the year 2001. Developed countries were net importers of CO_2 emissions—meaning they consumed more carbon-intensive goods than they produced, importing the difference. This trend has grown: net emission transfers from developing to developed regions have increased substantially from 1990 to 2008. Global value chains play a key role in this process. The result is a geographic separation of "production emissions" from "consumption emissions." Developed economies appear to lower their territorial CO_2 emissions, but the emissions are effectively outsourced via trade.

1.1.4 *Elite Insulation and Willingness to Pay for Environmental Protection*

Another linkage between inequality and externalities is the political economy of environmental protection. In theory, as societies become wealthier, demand for environmental quality rises. However, when inequalities are stark, elites can insulate themselves from environmental harms, diminishing their willingness to pay for environmental protection. At the global scale, the richest individuals often shield themselves by outsourcing dirty production abroad. This decoupling of those who pay and those who suffer weakens political will for climate action.

High inequality facilitates the obstruction of climate policies by wealthy elites. These elites may resist carbon taxes or regulations that threaten their interests. In essence, extreme inequality leads to environmental moral hazard: those with the capacity to prevent harm have the least motivation to do so when they can avoid the consequences.

1.1.5 *Regressive Burdens of Environmental Externalities*

Environmental externalities are regressive because they fall disproportionately on poorer populations. Pollution and climate change impact vulnerable communities more severely due to lack of infrastructure, healthcare, and political voice. The poor often live in more polluted areas, have fewer options for adaptation, and suffer long-term losses in education, income, and health. Globally, low-income countries—despite contributing little to climate change—are most vulnerable to its impacts. This mismatch among spatial and social classes raises critical questions of climate justice.

Combining these insights, we see that inequality drives trade-based environmental externalities. The affluent in the some countries consume carbon-intensive goods produced in other countries, where pollution occurs. This separation allows the top elite class to enjoy the benefits of global trade while externalizing costs. High inequality incentivizes this dynamic, and increase the severity of climate change.

1.2 The Existing Literature

This section reviews the literature linking income inequality, international trade, and carbon emissions. It synthesizes empirical findings and theoretical insights from environmental economics, political economy, and trade theory to contextualize the empirical analysis presented in this paper.

1.2.1 *Inequality and Carbon Emissions*

A growing body of research confirms that income inequality is a major driver of carbon emissions. High-income individuals—particularly those in the top 1% and 10%—contribute disproportionately to global emissions due to their consumption-intensive lifestyles. Chancel and Piketty (2015), and later Chancel (2022), estimate that the top 10% are responsible for nearly half of global CO_2 emissions, while the bottom 50% account for just around 12% [6].

The political economy perspective advanced by Boyce (1994) suggests that inequality not only increases emissions via consumption but also weakens environmental regulation by diluting the political power of those most affected by pollution [7]. This idea is reinforced by Jorgenson et al. (2017) and Grunewald et al. (2017), who find that countries with higher income concentration tend to have higher per capita emissions, especially in advanced economies.

Moreover, the "Veblen effect"—wherein elite overconsumption leads to aspirational behavior and longer work hours across social strata—amplifies carbon output. This effect, discussed by Jorgenson et al. (2016) and formalized by Bowles and Park (2005), shows how inequality drives unsustainable social consumption norms [8]. Liu et al. (2019) further emphasize that spatially clustered income inequality intensifies emissions, illustrating how geography compounds inequality's environmental impacts [9].

1.2.2 *Trade, Carbon Leakage, and Structural Change*

International trade plays a crucial role in shaping the geography of emissions. The Pollution Haven Hypothesis (PHH) posits that trade liberalization enables high-income countries to outsource pollution-intensive production to countries with weaker environmental regulations. Empirical work by Peters and Hertwich (2008) and Grether et al. (2010) confirms that developed countries are often net importers of emissions, while developing economies bear the production costs [10], [11].

Davis and Caldeira (2010) estimate that approximately 23% of global emissions are embedded in trade flows, reinforcing the case for consumption-based (Scope 3) accounting [12]. Kanemoto et al. (2016) map these emissions transfers, revealing systematic patterns of environmental outsourcing from the Global North to the Global South [13].

Recent contributions have shifted attention to trade structure. Wang et al. (2023) find that while trade openness can increase emissions at lower income levels, trade diversification—particularly on the import side—reduces overall emissions by promoting structural change and technological upgrading [14]. Ragoubi and Mighri (2020) confirm this in a spatial context, showing that trade openness has direct positive effects on emissions but also generates indirect negative spillovers that reduce emissions in neighboring middle-income countries [15].

1.2.3 *The Environmental Kuznets Curve*

The Environmental Kuznets Curve (EKC) hypothesis suggests an inverted-U relationship between income and environmental degradation: emissions initially rise with income growth but eventually decline as societies develop cleaner technologies and stronger institutions [16]. While widely cited, this hypothesis has come under increasing scrutiny.

Li et al. (2019) challenge the EKC's generalizability by showing that spatially uneven income distributions in China amplify emissions, contradicting the idea of automatic decoupling of growth and pollution [9]. Similarly, Shabani et al. (2024) demonstrate that good governance and renewable energy adoption produce negative spillover effects on emissions, implying that transnational policy coordination is essential for realizing the EKC's long-term benefits [17].

Wang et al. (2023) and Ragoubi and Mighri (2020) further complicate the EKC narrative by showing that trade openness and diversification interact with national income structures to produce asymmetric outcomes. These findings underscore the importance of accounting for structural inequality and trade composition when evaluating environmental trajectories.

1.2.4 *Theoretical Implications*

Beyond empirical correlations, inequality has deeper theoretical implications for environmental policy. Traditional Pigouvian approaches advocate for taxing emissions at the level of their marginal social cost. However, this framework assumes a representative agent and overlooks distributional effects. Stiglitz (2017) argues for climate policies that incorporate equity concerns, warning that flat carbon pricing can be regressive unless paired with redistributive measures [18].

Building on this critique, Boyce (1994) introduces the concept of inequality-weighted environmental impacts, which suggests that pollution concentrated in poor communities is not only unjust but also politically harder to control [7]. In this light, redistributive taxation, progressive carbon pricing, and income-sensitive mitigation strategies emerge as key tools for achieving both environmental and social goals.

Together, these literatures emphasize the need to move beyond one-dimensional models of growth and emissions. Inequality and trade not only shape who emits, but also who bears the cost—and who holds the power to change course. This research contributes to the field by integrating these strands into a unified empirical framework that examines how income concentration and trade dynamics jointly influence CO_2 emissions.

1.3 Stylized Facts

A preliminary look at the data reveals several patterns that motivate this study. Global CO_2 emissions from fossil fuels and industry have risen sharply over the past two centuries (Figure 1.1), with a dramatic acceleration after 1950. This increase reflects rapid industrialization, global trade expansion, and the growing energy demands of modern economies.These stylized facts emphasize that both where and who emits matters, motivating a disaggregated and equity-based approach to analyzing global carbon inequality.

More recently, emissions have become increasingly concentrated among a handful of countries (Figure 1.2). China and the United States dominate in absolute territorial emissions, with China surpassing the U.S. in the early 2000s. Other major emitters include India, Russia, and Brazil, while countries like Germany and the UK show declining or plateauing emissions.

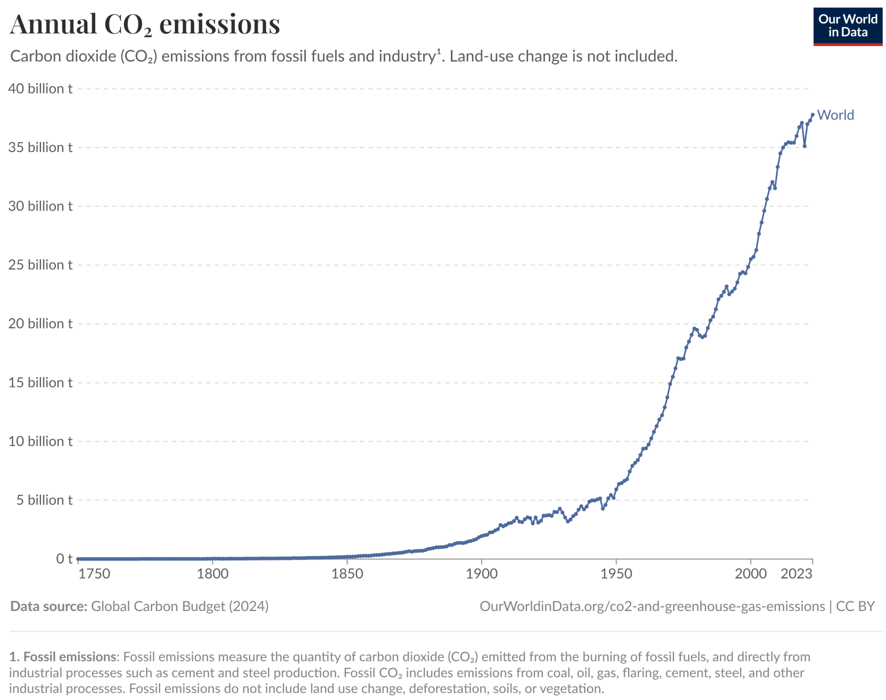

Figure 1.1: Global Annual CO_2 Emissions from Fossil Fuels and Industry, 1750–2023

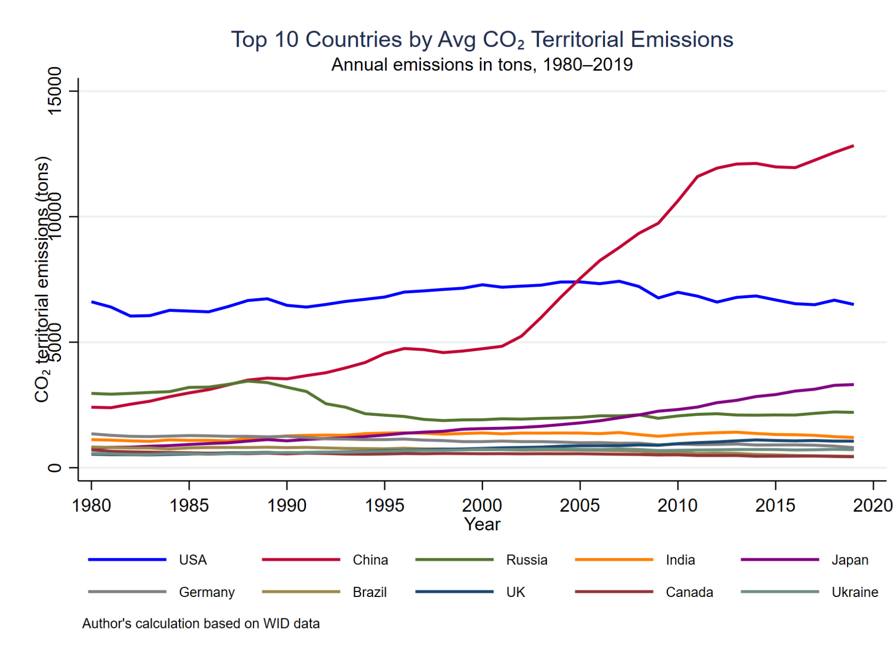

Figure 1.2: Top 10 Countries by Avg CO_2 Territorial Emissions, 1980–2019

Yet a closer look reveals that not just countries, but specific income groups within them are driving this growth. To illustrate the scale of global carbon inequality, we replicated a key figure from [1] using data from the World Inequality Database (WID). I computed the approximate global shares of CO_2 emissions for four income groups—Bottom 50%, Middle 40%, Top 9%, and Top 1%—by aggregating national-level percentile emissions across all countries in 2022. The results show a highly skewed distribution: the Top 1% alone account for approximately 17.9% of global emissions, while the Top 9% emit nearly 69.4%. In contrast, the Middle 40% and Bottom 50% contribute around 8.3% and 4.4%, respectively. These numbers differ from the original estimates in ([1]), which report 12% for the Bottom 50%, 40.4% for the Middle 40%, 30.8% for the Top 9%, and 16.8% for the Top 1%. Their calculations are based on globally harmonized individual-level simulations that weight individuals by population and include consumption-based emissions (Scope 3), using detailed input–output modeling and microdata from tax records and household surveys. My replication, while simpler, confirms the same stylized fact: global CO_2 emissions are overwhelmingly driven by the consumption patterns of the richest decile, and especially the top percentile.

Figure 1.4 illustrates the stark inequality in per capita CO_2 emissions across global income groups. Using World Inequality Database (WID) data for 2022, I compute the average consumption-based CO_2 emissions per person for four major groups: Bottom 50%, Middle 40%, Top 9%, and Top 1%. The results reveal that the Top 9% emit an average of 43.9 tonnes per person annually, compared to just 2.0 tonnes for the Bottom 50% and 3.9 tonnes for the Middle 40%. The Top 1% emit 8.8 tonnes, still significantly above the global average. While these estimates align with the overall structure reported in [1], they differ in magnitude due to dif-

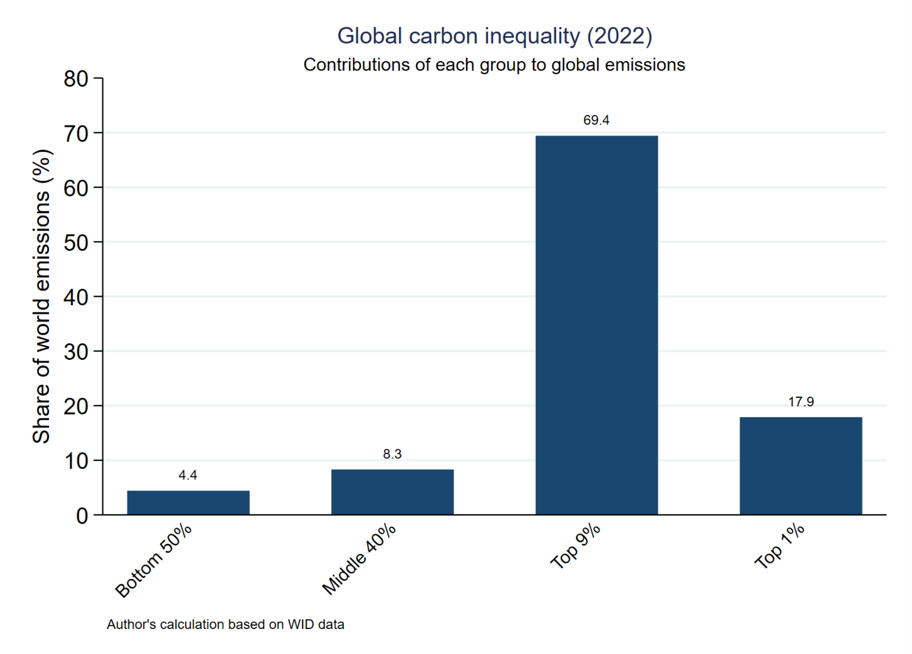

Figure 1.3: Global Carbon Inequality (2022)

ferences in methodology. Chancel's estimates rely on micro-simulated income and emissions distributions with full population weighting, whereas my approach aggregates national-level per capita indicators from WID. Nonetheless, both approaches reinforce the same stylized fact: per capita CO_2 emissions rise sharply with income, especially within the richest deciles.[1]

[1]Personal carbon footprints include emissions from domestic consumption, public and private investments as well as imports and exports of carbon embedded in goods and services traded with the rest of the world. Modeled estimates are based on the systematic combination of tax data, household surveys and input-output tables. Emissions are split equally within households. Source and series: Chancel (2021).

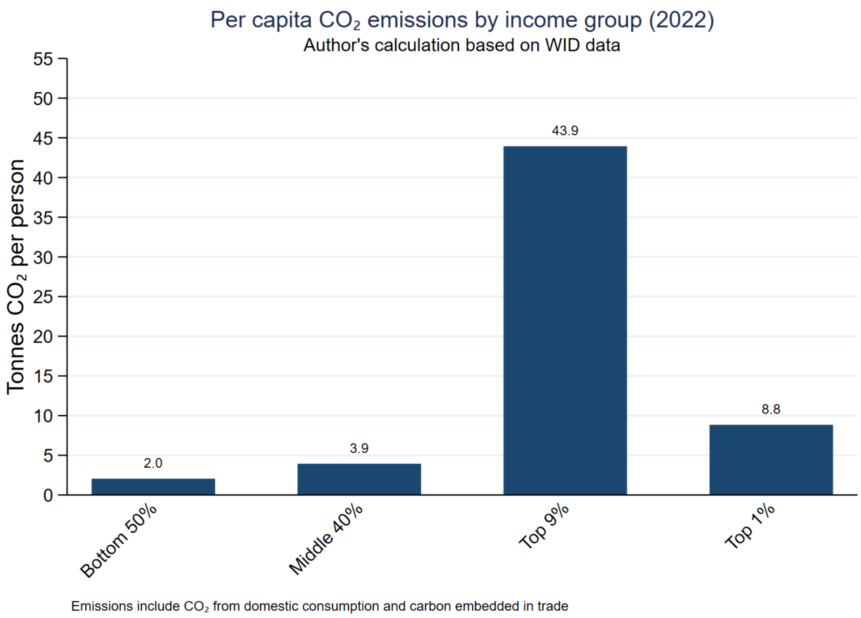

Figure 1.4: Per Capita Carbon Emissions by Income Group (2022)

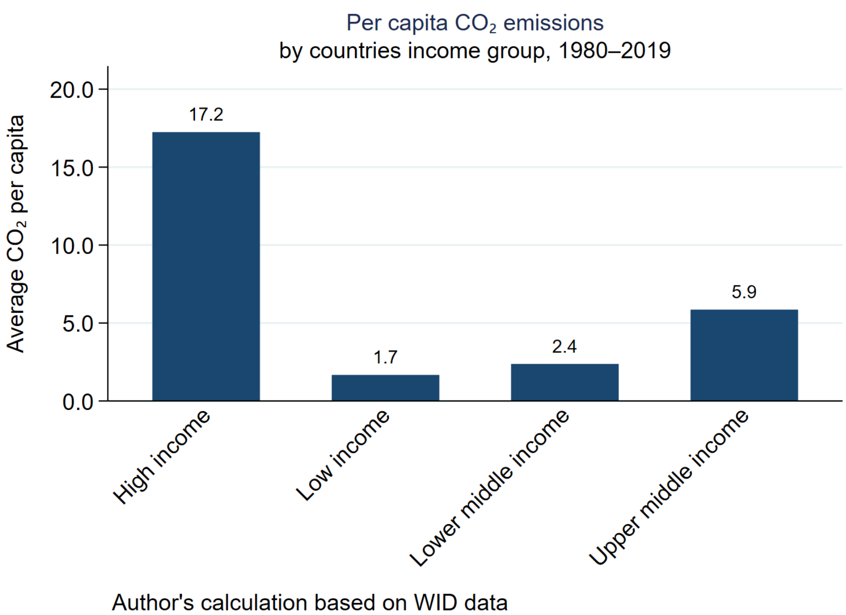

Figure 1.5: Per capita CO_2 emissions by countries' income group (tons of CO_2, 1980–2019

Figure 1.5 displays the average per capita CO_2 emissions (in tons per person per year) for countries grouped according to the World Bank income classification over the period 1980–2019. High-income countries exhibit the highest levels of per capita emissions, averaging 17.2 tons annually. In contrast, low-income countries emit only

1.7 tons per capita on average. Upper-middle income countries reach 5.9 tons, while lower-middle income countries average 2.4 tons.

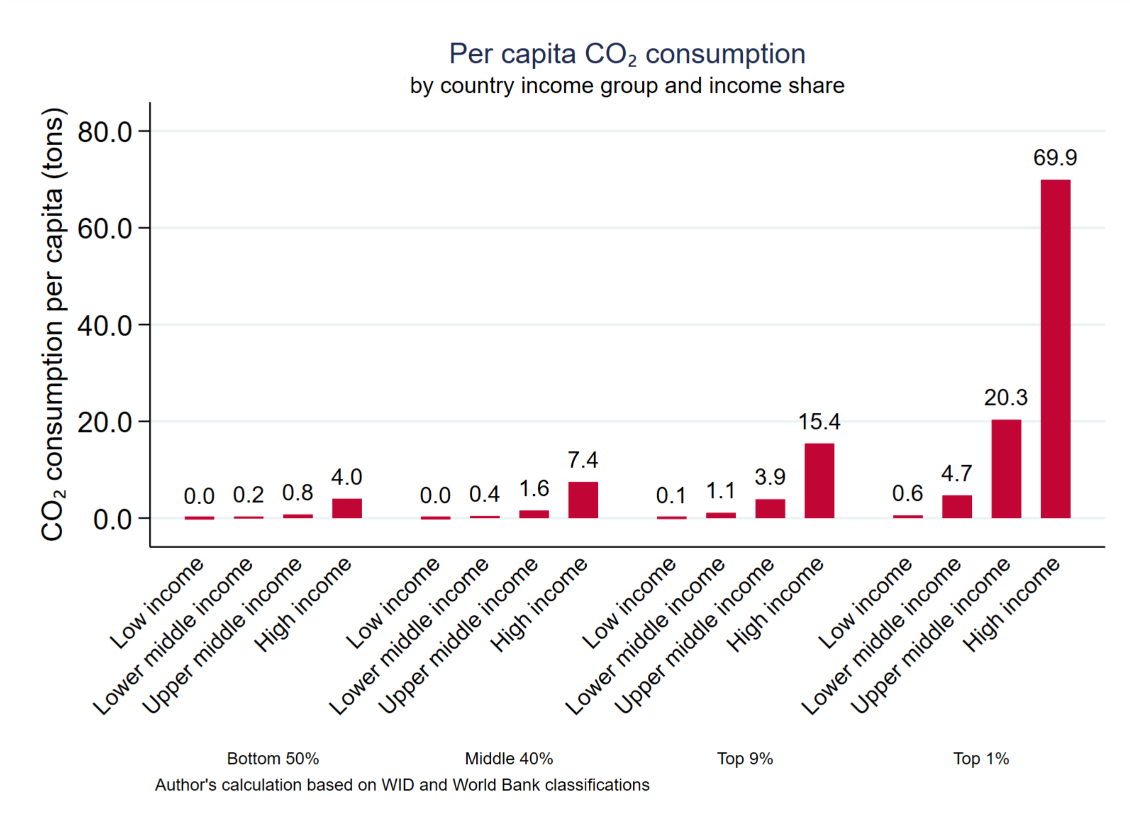

Figure 1.6: Per capita consumption-based CO_2 emissions by country income group and population income share

Figure 1.6 shows average per capita CO_2 emissions from final consumption (Scope 3) for four income shares—Bottom 50%, Middle 40%, Top 9%, and Top 1%—across World Bank income groups. These are not territorial emissions, but instead reflect the carbon footprint generated through the consumption of goods and services, including imported emissions embedded in trade. The disparities are profound: in high-income countries, the top 1% emits an average of 69.9 tons per person annually, compared to just 4 tons for the bottom 50%. In upper-middle income countries, the top 1% emits more than 5 times as much as the bottom 50%. In contrast, in low-income countries, consumption-based CO_2 emissions are extremely low across all groups. These patterns underscore the carbon inequality embedded in consumption itself, with the wealthiest segments of populations in richer countries responsible for the majority of global demand-driven emissions.

This pattern reflects the persistent global asymmetries in carbon emissions, where wealthier countries are responsible for a disproportionately large share of emissions per person. These disparities emphasize the need for differentiated climate responsibilities and equitable policy frameworks in addressing global environmental challenges.

Table 1.1: Carbon footprints vs. territorial emissions across the world, 2019

Region	**Footprint** (tCO_2/capita)	**Territorial** (tCO_2/capita)	**% Difference** (Footprint vs. Territorial)
World	6.6	6.6	0%
Sub-Saharan Africa	1.6	2.1	-22%
South South-East Asia	2.6	2.7	-5%
Latin America	4.8	4.9	-2%
Middle East	7.4	8.0	-7%
East Asia	8.6	9.4	-8%
Europe	9.7	7.9	+23%
Central Asia / Russia	9.9	11.9	-17%
North America	20.8	19.8	+5%

Source and series: [1]. Carbon footprints include emissions from domestic consumption, public and private investments, and net imports embedded in goods and services. Territorial emissions reflect emissions produced within a country's borders.

Table 1.1 compares per capita carbon footprints (consumption-based emissions) with territorial emissions (production-based emissions) across major global regions in 2019. The world average for both metrics is identical at 6.6 tCO_2/capita. However, notable regional disparities emerge when examining the difference between these two accounting frameworks.

Regions such as Europe (+23%) and North America (+5%) show higher consumption-based emissions than territorial ones, indicating that these areas are net importers of carbon-intensive goods. This reflects the externalization of emissions through global trade, where consumption in high-income countries relies on production elsewhere.

In contrast, Sub-Saharan Africa (-22%), Central Asia/Russia (-17%), and East Asia (-8%) have significantly lower footprints than their territorial emissions, positioning them as net exporters of carbon emissions. These economies often serve as manufacturing hubs or commodity suppliers, generating emissions to satisfy external demand.

This gap highlights the asymmetry in global emissions responsibility: territorial accounting underestimates the climate burden of affluent, consumption-driven economies while over-assigning responsibility to producer regions. These findings reinforce the argument for using consumption-based indicators—like carbon footprints—to assess climate accountability and shape equitable mitigation policies.

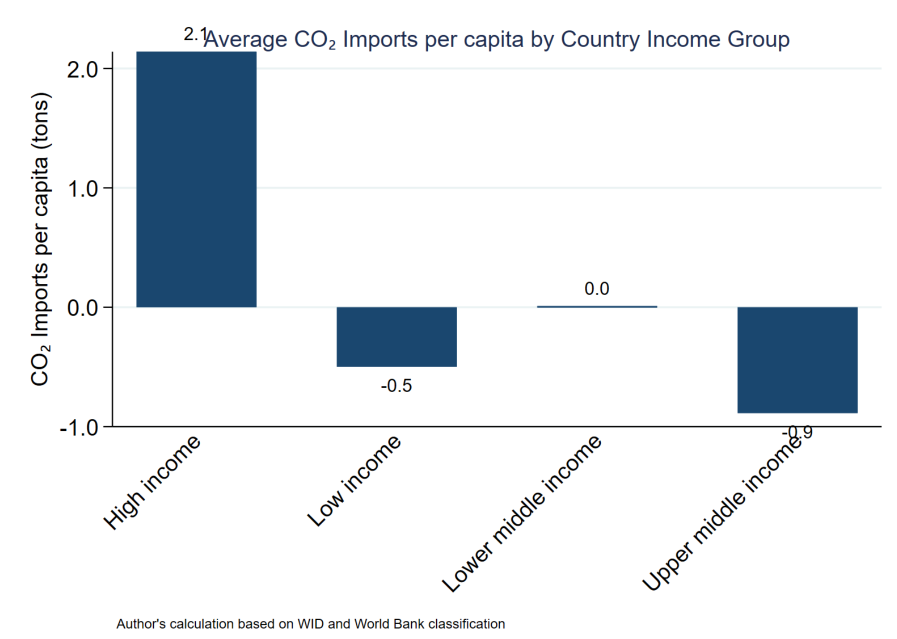

Figure 1.7: Average CO_2 imports per capita by country income group (1980–2019). High-income countries import significantly more carbon-intensive goods, while low- and lower-middle-income countries are net exporters of CO_2 emissions.

Figure 1.7 illustrates average per capita CO_2 imports across countries income groups. High-income countries exhibit the highest levels of CO_2 imports per capita (approximately 2.1 tons), consistent with their role as net importers of carbon-intensive goods and services. This reinforces the observation that advanced economies externalize significant portions of their carbon footprint through global trade—effectively shifting emissions to producer countries in the Global South.

By contrast, low-income and lower-middle-income countries show close to zero or even negative per capita CO_2 imports. This suggests that their production-based emissions exceed those attributable to their own consumption—highlighting their role as net exporters in the global carbon economy. The negative values imply that emissions are being generated domestically to meet external demand, especially in manufacturing or extractive sectors.

This distribution supports the broader thesis that trade amplifies global carbon inequality. High-income nations consume beyond their territorial emissions limits by importing embodied emissions, while low- and middle-income countries disproportionately shoulder the environmental burden of global consumption.

The following graphs compare per capita CO_2 emissions and CO_2 imports across countries classified by the IMF as either Advanced Economies or Emerging and Developing Economies (EMDEs).

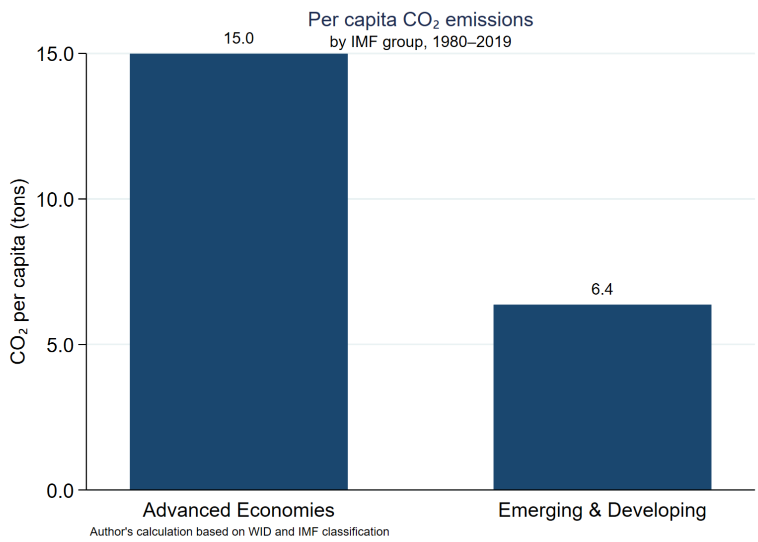

Figure 1.8: Per capita CO_2 emissions by IMF group, 1980–2019.

Figure 1.8 shows that Advanced Economies emit an average of 15 tons of CO_2 per person, while EMDEs emit only 6.4 tons. This stark contrast underscores the emissions inequality between industrialized and developing regions.

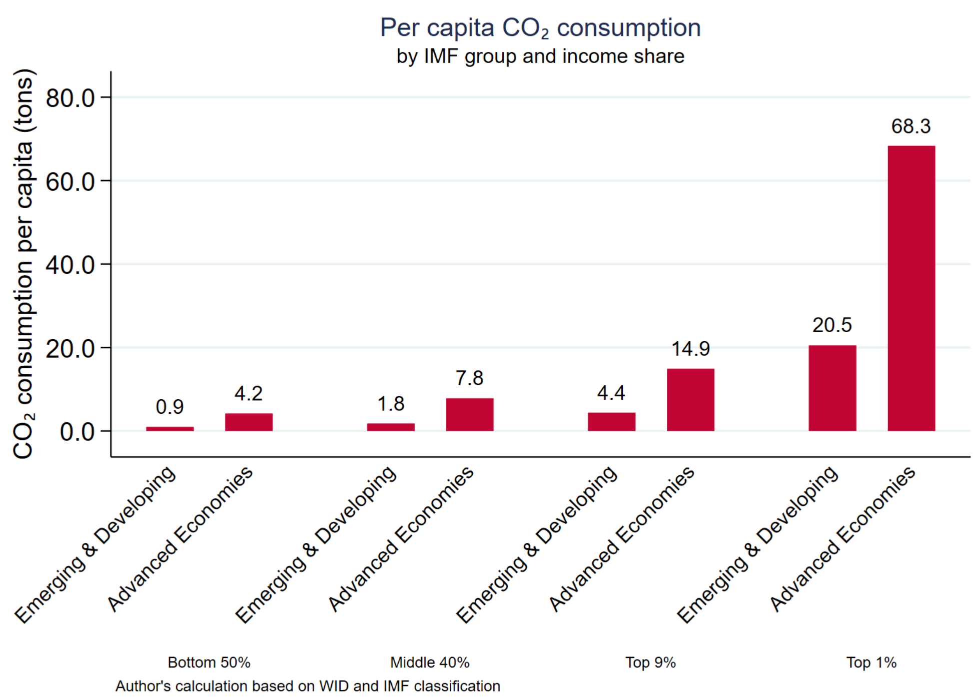

Figure 1.9: Per capita CO_2 consumption by IMF group and income share.

Figure 1.9 illustrates how CO_2 consumption per capita differs between income groups (Bottom 50%, Middle 40%, Top 9%, and Top 1%) across Advanced Economies and Emerging and Developing Economies (EMDEs).

The disparities are stark. In Advanced Economies, the top 1% alone is responsible for an average of 68.3 tons of CO_2 consumption per capita—over 16 times more than their counterparts in EMDEs (20.5 tons). Even among the top 9%, inequality persists: individuals in Advanced Economies emit more than three times as much CO_2 as their peers in EMDEs.

At the lower end of the distribution, the Bottom 50% in Advanced Economies consume nearly five times more CO_2 (4.2 tons) than those in EMDEs (0.9 tons). These results demonstrate how both international inequality and within-country income concentration shape global environmental burdens, with the wealthiest elites in rich nations contributing disproportionately to consumption-based emissions.

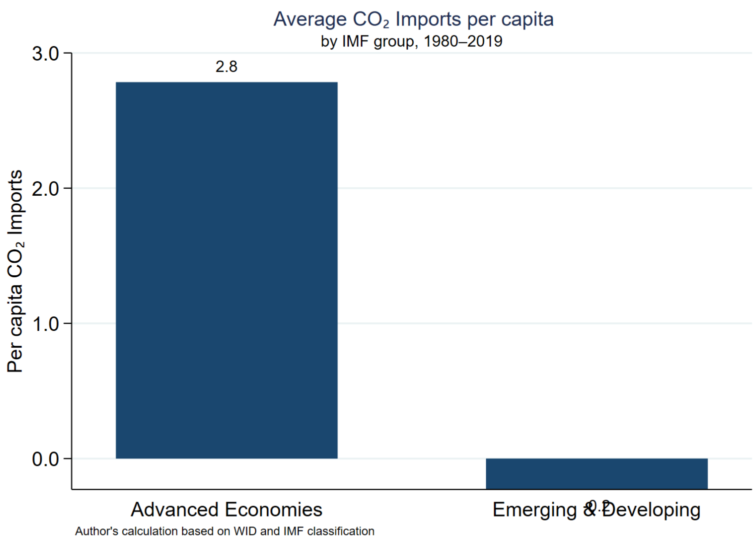

Figure 1.10: Average CO_2 imports per capita by IMF group, 1980–2019.

Figure 1.10 further reveals that Advanced Economies also import significantly more CO_2-embedded emissions—averaging 2.8 tons per person—compared to near-zero import levels in EMDEs. This highlights how high-income countries not only emit more but also effectively outsource part of their environmental footprint to the Global South through international trade.

1.4 Contribution and Main Findings

This paper contributes to the growing literature on climate inequality by empirically linking income concentration, global trade, and carbon emissions using a comprehensive panel dataset spanning 160 countries over the period 1980 to 2019.The empirical analysis shows that income inequality, particularly the share of national income held by the top 9%, is a consistently strong predictor of higher CO_2 emissions across all key metrics, including total and per capita carbon footprints and territorial emissions. This relationship holds across different stages of development and is especially pronounced for production-based emissions, where elasticities exceed 1.2 in some specifications. While the top 1% income share is not always statistically significant on its own, it plays a crucial role when interacting with trade and import flows. Specifically, the interaction between the top 1% income share and trade openness is significantly negative, suggesting that in more unequal societies, greater trade integration is associated with lower domestic emissions—likely through the offshoring of carbon-intensive production. At the same time, the interaction between the top 1% income share and CO_2 imports is significantly positive, indicating that inequality at the top fuels the outsourcing of emissions through luxury and high-carbon imported consumption.

These global patterns are reinforced when the analysis is disaggregated by development level. In high-income countries, the top 1% is strongly associated with increased emissions, while the broader upper class (top 9%) tends to exhibit a negative or insignificant relationship, reflecting a divergence in carbon intensity within the elite. In lower-middle-income countries, both top income groups are associated with higher emissions, but these effects appear to operate primarily through domestic consumption, as trade interaction terms are generally weak or insignificant. Low-income countries exhibit a similar pattern, though with even stronger evidence of emissions outsourcing: here, the top 1% income share is positively associated with CO_2 imports and territorial emissions per capita, suggesting that even in poorer nations, elite consumption patterns replicate the global dynamics of environmental inequality. These findings are consistent with recent literature emphasizing the spatial displacement of emissions through trade, and they align with earlier theoretical work by Boyce (1994), Liu et al. (2019), and Kanemoto et al. (2016), who highlight the uneven distribution of both carbon responsibility and climate vulnerability.

Moreover, by stratifying the regression models across both World Bank income classifications and the IMF's advanced versus emerging economy typology, the study uncovers important heterogeneities. In emerging and developing economies, the top 9% is the main driver of territorial emissions, while the top 1% is more strongly associated with CO_2 imports—pointing to different channels through which inequality operates. In contrast, in advanced economies, the top 1% income share drives both production- and consumption-based emissions, with a partially mitigating role played by trade openness. These findings lend further support to calls for differentiated climate policies that account for elite overconsumption and carbon leakage, especially as global inequality intensifies.

This research fills a significant empirical gap by demonstrating how elite income concentration interacts with global trade to shape both the scale and geography of carbon emissions. It contributes a novel empirical framework that brings together inequality, trade, and environmental externalities in a unified analysis, offering new evidence on how global carbon responsibility is structured not just between nations, but within them.

The rest of the thesis is structured as follows. Chapter 2 presents the theoretical framework that models the relationship between income inequality, trade, and

CO externalities. Chapter 3 describes the data sources, variable construction, and econometric methodology. Chapter 4 presents the empirical results and interprets the main findings across different country classifications. Chapter 5 concludes with a summary of contributions, policy implications, and directions for future research.

Chapter 2

Theoretical Framework

This chapter develops a theoretical framework to understand the interaction between global income inequality and international trade in the generation and spatial distribution of environmental externalities. The framework builds on classical externality theory [19], recent literature on structural inequality [1], and models linking trade and environmental degradation [5], [20]. Our primary objective is to explore how high-income groups and rich countries externalize greenhouse gas (GHG) emissions to lower-income groups or low-income regions, particularly through trade, while the resulting climate damages remain unevenly distributed.

We distinguish between production-based emissions—those generated during the production of goods and services within a country—and consumption-based emissions, which are embedded in the goods and services consumed by individuals, regardless of the production location. This distinction is central in a globalized economy where trade enables the spatial decoupling of consumption and emissions. In later sections, we show how this spatial shift is modeled formally.

2.1 Overview and Motivation

CO_2 emissions provide a canonical example of negative externalities: economic agents emit greenhouse gases without internalizing the social cost. According to Pigouvian theory, this results in excessive production of polluting goods. When the marginal social cost exceeds the marginal private cost, the market equilibrium is inefficient, producing more pollution than socially optimal. As Pigou wrote, when "the private and social net products of a factor diverge," the market "tends to direct resources into channels in which they are less productive socially than they would be elsewhere" [19]. Without corrective policies—such as taxes, regulation, or permit systems—this distortion persists.

Globally, this inefficiency is amplified by two structural features:

1. **International trade**, which enables carbon-intensive production to relocate to countries with weaker regulations.

2. **Global income inequality**, which shapes consumption patterns, regulatory capacity, and exposure to climate-related damages.

Empirical evidence confirms these dynamics: the top 1% of the global income distribution emits more CO_2 than the bottom 50% combined [1], and high-income countries routinely outsource carbon-intensive production to lower-income countries [5]. This creates a disjunction between the location of emissions and the locus of climate vulnerability.

2.2 Model Setup

We begin with a closed economy comprising G income groups indexed by $g = 1, 2, \ldots, G$. Group g earns income y_g, with total income $y = \sum_{g=1}^{G} y_g$ and income share $s_g = \frac{y_g}{y}$. Each group consumes L goods indexed by $l = 1, 2, \ldots, L$, priced at 1. Let c_l^g be the consumption of good l by group g. Each group solves:

$$\max_{\{c_l^g\}} U_g = U(c_1^g, \ldots, c_L^g) \quad \text{s.t.} \quad \sum_{l=1}^{L} c_l^g = y_g$$

Assuming U_g is strictly increasing, concave, and differentiable, the first-order condition implies:

$$\frac{MU_l^g}{MU_{l'}^g} = 1 \quad \forall l, l'$$

Each good l is associated with emissions intensity θ_l. Total emissions from group g are:

$$e_g = \sum_{l=1}^{L} \theta_l c_l^g,$$

and total emissions in the economy are:

$$E = \sum_{g=1}^{G} e_g = \sum_{g=1}^{G} \sum_{l=1}^{L} \theta_l c_l^g.$$

2.3 Social Optimum and Externality

A social planner maximizes aggregate utility while internalizing the environmental damages from emissions. Let $D(E)$ denote the convex damage function. The planner solves:

$$\max_{\{c_l^g\}} \sum_{g=1}^{G} U_g(c_1^g, \ldots, c_L^g) - D\left(\sum_{g=1}^{G} \sum_{l=1}^{L} \theta_l c_l^g \right).$$

The first-order condition becomes:

$$\frac{MU_l^g}{MU_{l'}^g} = \frac{\theta_l}{\theta_{l'}} \quad \forall l, l'.$$

This implies that the optimal consumption mix favors low-emission goods. The gap between the planner and market allocation increases with emission intensity dispersion and marginal damages.

2.4 Distributional Effects and Emission Distortion

Redistributing income from a lower-income group g to a richer group g' (i.e., $dy_g = -dy_{g'}$) raises aggregate emissions even if total income remains constant. This is because the marginal propensity to emit rises with income:

$$\frac{\partial e_g}{\partial y_g} < \frac{\partial e_{g'}}{\partial y_{g'}} \quad \text{for} \quad y_g < y_{g'}.$$

To formalize, assume Cobb–Douglas preferences:

$$U_g = \prod_{l=1}^{L} (c_l^g)^{\alpha_l^g}, \quad \sum_l \alpha_l^g = 1.$$

Budget constraint: $\sum_l c_l^g = y_g$. Marshallian demand: $c_l^g = \alpha_l^g y_g$. Let θ_l be each good's emissions intensity. Then:

$$e_g = \sum_l \theta_l c_l^g = y_g \sum_l \theta_l \alpha_l^g \equiv y_g \bar{\theta}_g,$$

where $\bar{\theta}_g$ is group g's average emissions intensity. Hence:

$$\frac{\partial e_g}{\partial y_g} = \bar{\theta}_g.$$

If richer groups allocate more to high-θ_l goods, then $\bar{\theta}_g$ is increasing in y_g. Thus:

$$\frac{\partial e_g}{\partial y_g} < \frac{\partial e_{g'}}{\partial y_{g'}}.$$

This formally shows how inequality amplifies emissions by shifting income toward high-emission consumption patterns.

2.5 International Trade Extension

Now assume N countries indexed by $i = 1, \ldots, N$. Each country has its own income distribution $\{y_{ig}\}$ and sector-specific emissions intensities θ_l^i. Countries also differ in their regulatory enforcement, denoted by $\tau_i \in [0, 1]$, where $\tau_i = 1$ represents full internalization of environmental externalities (i.e., strong regulations), and $\tau_i \approx 0$ indicates weak or no enforcement.

Each country produces goods for both domestic consumption and export. Let total output in country i be:

$$Y_i = C^i_{\text{domestic}} + X^i_{\text{exports}},$$

and let total territorial emissions be:

$$e_i = \theta_i Y_i = \theta_i (C^i_{\text{domestic}} + X^i_{\text{exports}}),$$

where θ_i captures the average emissions intensity of production in country i.

When τ_i is close to zero, producers face little to no penalty for pollution, leading to overproduction of emission-intensive goods. We define Y_i^T and e_i^T as the trade-influenced equilibrium levels of output and emissions under weak regulation. By contrast, Y_i^* and e_i^* denote the socially optimal levels of production and emissions under full internalization of externalities.

$$\text{If } \tau_i \approx 0, \quad Y_i^T > Y_i^* \quad \text{and} \quad e_i^T > e_i^*.$$

In countries with strong environmental regulation ($\tau_i \approx 1$), the trade-influenced outcome converges toward the social optimum. Therefore, the divergence between T and $*$ depends critically on the country's regulatory capacity.

2.6 Testable Implications

The theoretical framework yields three main testable hypotheses:

- **H1 (Income Concentration and Carbon Leakage):** Countries with high income concentration (e.g., top 1% or 9% income shares) are more likely to be net importers of CO_2 emissions. This is reflected in their consumption-based emissions exceeding their territorial (production-based) emissions.

- **H2 (Trade and Territorial Emissions):** In countries with weak regulatory enforcement, greater trade openness is associated with higher territorial CO_2 emissions. That is, when producers face few constraints, increased trade leads to more domestic pollution.

- **H3 (Income Concentration and Total Emissions):** Countries with high income concentration tend to generate higher total CO_2 emissions. This results from the disproportionately carbon-intensive consumption of top earners.

These predictions are tested using panel data on income shares, trade openness, and emissions (footprint vs. production). Potential endogeneity (e.g., reverse causality) is addressed via country and year fixed effects.

Chapter 3

Data and Methodology

3.1 Data

Our empirical analysis relies on a balanced panel dataset of a wide range of economic and environmental indicators, covering 160 countries from 1980 to 2019. The data were constructed by merging multiple sources, including the World Inequality Database (WID), and the World Bank's World Development Indicators (WDI).

3.1.1 *Variable Definitions and Measurement Concepts*

In the following we will provides precise definitions and sources for the environmental, trade, and inequality-related variables used in this study. These indicators stem primarily from the World Inequality Database (WID), where carbon emissions are attributed to individuals based on both territorial production and consumption principles, using environmentally extended multi-regional input-output (EE-MRIO) modeling techniques.

Inequality and Trade Variables

- **Income Shares**: The share of total national income received by specific income groups (e.g., top 1%, top 9%, bottom 50%). These are measured using harmonized income concepts from the WID based on fiscal, survey, and national accounts data.

- **National Income**: Aggregate pretax national income, used to compute income by group and expressed in constant purchasing power parity (PPP) units. It corresponds to the total sum of income generated within a country before redistribution.

- **Population**: Refers to the population of individuals of all ages, consistent with the income and carbon attribution methods used in the WID framework.

- **Trade Openness**: The sum of exports and imports as a percentage of GDP, obtained from the World Bank's World Development Indicators.

- **Industrial Share of GDP**: The share of GDP attributed to the industrial sector (including manufacturing, mining, construction, and utilities), serving as a proxy for the economic structure and its environmental intensity.

Carbon Emission Variables

The carbon data in our analysis are also drawn from the World Inequality Database's aggregate carbon footprint series, based on Environmentally Extended Multi-Regional Input-Output (EE-MRIO) tables. The EE-MRIO tables consist in a classic MRIO table detailing the value of transactions between each sector/country pair included in the framework and an extension of environmental accounts offering the possibility to assess the environmental effects of each of these transactions.

This classification of emissions follows the internationally recognized framework of Scope 1, 2, and 3 emissions, as defined by the U.S. Environmental Protection Agency (EPA) and the Greenhouse Gas Protocol [21]. In particular:

- **Scope 1 Emissions**: Scope 1 emissions are emissions directly emitted by a set of organizations. Emissions are directly emitted if they come from sources that are detained or controlled by the organization. Aggregate scope 1 emissions at the national level consist in the aggregation of all scope 1 emissions of organizations in the country.

- **Scope 2 Emissions**: Scope 2 emissions encompass scope 1 emissions as well as indirect emissions associated with electricity, heat or steam imported to support the economic activity of the organization.

- **Scope 3 Emissions**: Scope 3 emissions encompass scope 2 emissions as well as other emissions indirectly produced and linked with the complete chain of value of the activities of an organization

Following the WID.world Technical Note 2021/03 [22], the key definitions used are:

- **CO_2 Footprint (Consumption-Based Emissions)**: Refers to the total level of emissions induced by final demand in a given country. It is equal to the sum of domestic emissions net of exports and imported emissions. Total footprint can only be captured through a consumption-based accounting methodology. Carbon footprint corresponds to *scope 3* emissions. Unlike for domestic (or territorial) emissions, a carbon footprint can be attributed to an individual consumer as the sum of emissions produced to satisfy the consumption of this individual

- **Territorial CO_2 Emissions (Production-Based Emissions)**: Territorial emissions are emissions produced within a country's borders by households, businesses, and institutions (including exports). These correspond to *scope 1* emissions and are used in production-based carbon accounting (PBA).

- **Per Capita Territorial Emissions**: Territorial CO_2 emissions divided by the population comprised of individuals of all ages, capturing emissions from domestic production activity per individual.

- **$\mathbf{CO_2}$ Imports**: These are emissions embedded in goods and services produced abroad to meet domestic final demand. They include both direct imports—goods consumed directly by households—and indirect or "gray" imports, where foreign intermediate inputs are used in domestic production that ultimately serves domestic consumption.[1]

- **$\mathbf{CO_2}$ Personal Consumption by Income Group**: This refers to consumption-based emissions allocated to individuals by percentile groups (e.g., top 1%, top 9%, bottom 50%) using distributional national accounts. These values are derived from consumption expenditure patterns and environmental intensity coefficients of different consumption categories.

This accounting framework enables us to distinguish between emissions due to local production (territorial) and those driven by consumption (carbon footprint), capturing the transnational nature of environmental externalities.

[1] The term *gray emissions* refers to greenhouse gas emissions embedded in imported intermediate goods that are used in domestic production. These emissions are not directly observed in the final consumption of households but indirectly contribute to a country's carbon footprint. They align with what the GHG Protocol categorizes as Scope 3 upstream emissions—emissions that occur in the supply chain outside the reporting entity's boundaries [23]. For a multi-regional input–output accounting perspective, see Peters and Hertwich [5].

Table 3.1: Summary of Key Variables and Definitions

Variable	Definition	Source
Income Shares	Share of national income received by each group.	WID
National Income	Pretax national income (PPP adjusted).	WID
Population	Population comprised of individuals of all ages (consistent across all WID variables).	WID
Trade Openness	Exports + imports as % of GDP.	World Bank WDI
Industrial Share	Share of GDP from industrial sector (manufacturing, mining, etc.).	World Bank WDI
Total Imports	Value of all goods and services imported, measured in constant USD.	World Bank WDI
CO_2 Footprint	Emissions induced by final demand (consumption-based). Includes territorial emissions plus CO_2 imports minus exports.	WID, EE-MRIO
CO_2 Footprint Per Capita	Emissions induced by final demand (consumption-based) divided by total population.	WID, EE-MRIO
CO_2Territorial Emissions	Emissions produced within a country's borders. Includes direct emissions by households and firms.	WID, Global Carbon Project, PRIMAP
CO_2Territorial Emissions Per Capita	Territorial emissions divided by total population.	WID, PRIMAP
CO_2 Imports	Emissions embedded in imported goods and services consumed domestically.	WID, EORA MRIO
CO_2 Personal Consumption	Group-level footprint based on consumption expenditure and carbon multipliers.	WID Distributional Environmental Accounts

Note: Carbon footprint and personal consumption variables are constructed using the environmentally extended multi-regional input-output (EE-MRIO) approach and distributional environmental accounting developed by the World Inequality Lab. For details, Burq and Chancel [22] and Chancel and Rehm [24].

3.2 Methodology

3.2.1 *Empirical Strategy*

This study investigates the relationship between income inequality, trade flows, and CO_2 emissions. Specifically, it examines how the income shares of the richest groups (top 1% and top 9%) interact with trade openness and imports to shape a country's CO_2 footprint, territorial emissions, and CO_2 imports. The analysis also assesses whether these relationships vary across different types of emissions and income classifications. The empirical framework is built using a balanced panel of 160 countries over the period 1980 to 2019.

3.2.2 *Econometric Models*

The primary estimation model is a log-log panel regression with country and year fixed effects. The baseline specification is:

$$\begin{aligned}\log(\mathrm{CO2}_{it}) = {} & \beta_1 \log(\mathrm{Top1}_{it}) + \beta_2 \log(\mathrm{Top9}_{it}) + \beta_3 \log(\mathrm{Trade}_{it}) \\ & + \beta_4 [\log(\mathrm{Top1}_{it}) \times \log(\mathrm{Trade}_{it})] + \beta_5 [\log(\mathrm{Top9}_{it}) \times \log(\mathrm{Trade}_{it})] \\ & + \beta_6 \log(\mathrm{Industry}_{it}) + \beta_7 \log(\mathrm{Imports}_{it}) + \beta_8 [\log(\mathrm{Top1}_{it}) \times \log(\mathrm{Imports}_{it})] \\ & + \beta_9 [\log(\mathrm{Top9}_{it}) \times \log(\mathrm{Imports}_{it})] + \alpha_i + \delta_t + \varepsilon_{it}\end{aligned} \tag{3.1}$$

Where:

- $\log(\mathrm{CO2}_{it})$ is the log of the dependent variable for country i at time t (e.g., CO_2 footprint, per capita footprint, production-based emissions, per capita produced emissions).
- $\log(\mathrm{Top1}_{it})$, $\log(\mathrm{Top9}_{it})$ are the logged income shares of the top income groups the top 1% and top 9% earners.
- $\log(\mathrm{Trade}_{it})$ is the log of trade openness as shares of GDP.
- $\log(\mathrm{Industry}_{it})$ captures the log of industrial share as a share of GDP.
- $\log(\mathrm{Imports}_{it})$ is the log of total import flows of each country.
- α_i are country fixed effects; δ_t are year fixed effects.
- ε_{it} is the idiosyncratic error term.

In addition to the full model with interaction terms, we separately estimate the relationship between CO_2 imports and income inequality by running reduced-form regressions for each income group independently. These regressions take the following simplified form:

$$\log(\mathrm{CO2Imports}_{it}) = \beta_k \log(\mathrm{IncomeGroup}_{it}) + \alpha_i + \delta_t + \varepsilon_{it} \tag{3.2}$$

Where:

- $\log(\text{CO2Imports}_{it})$ is the log of CO_2 imports for country i at time t.
- $\log(\text{IncomeGroup}_{it})$ is the log of the income share for one of the following groups: Top 1% income share, Top 9% income share, Top 10% income share, Middle 40% income share, Bottom 50% income share
- α_i and δ_t are country and year fixed effects.
- ε_{it} is the error term.

This approach allows us to isolate and compare the elasticity of CO_2 imports with respect to income concentration across the distribution. These specifications do not include trade or industrial structure controls, as the focus is solely on the distributional profile of emissions embedded in trade.

3.2.3 *Estimation Method and Justification*

The models are estimated using the `reghdfe` command in Stata, which allows for efficient absorption of high-dimensional fixed effects. The following choices are made to strengthen the empirical design:

- **Fixed Effects:** Country fixed effects (α_i) control for unobserved national characteristics that are time-invariant or evolve slowly over time, such as geography, baseline institutional quality, or long-run resource endowments. Year fixed effects (δ_t) capture global time-varying shocks and common trends affecting all countries, including oil price shocks, global technological changes, and the implementation of international climate agreements (e.g., the Kyoto Protocol).
- **Population Weights**: Regressions are weighted by national population to reflect the demographic scale of each country's contribution to emissions and inequality, and to prevent results from being dominated by small countries.
- **Clustered Standard Errors**: Standard errors are clustered at the country level to correct for serial correlation and heteroskedasticity within countries over time, ensuring robust inference.
- **Log-Log Specification**: All continuous variables are used in natural logarithmic form, allowing for elasticity interpretations. For instance, β_1 captures the percentage change in emissions associated with a 1% increase in the top 1% income share.

3.2.4 *Interaction Terms and Elasticity Interpretation*

To test whether inequality modifies the effect of trade and imports on emissions, the regressions include interaction terms between income shares and trade-related variables. The coefficients of these interaction terms show how the marginal effect of trade openness (or imports) on emissions changes as inequality increases. Because the specification is log-log, all coefficients—including interactions—can be interpreted as elasticities.

3.2.5 *Robustness Checks and Extensions*

To ensure the robustness of the results, several additional specifications are estimated:

- Models using different dependent variables:
  - log(CO2 Footprint), log(CO2 Footprint Per Capita)
  - log(Territorial Emissions), log(Territorial Emissions Per Capita)
  - log(CO2 Imports)
- Regressions by inequality group (top 1%, top 9%, top 10%, middle 40%, bottom 50%)
- Subsample regressions using income classifications from the World Bank and the International Monetary Fund (IMF).

3.2.6 *Country Group Classification and Heterogeneous Effects*

To explore heterogeneous effects of inequality and trade on emissions, the baseline model is extended to subsets of countries classified by income level. Two primary classification systems are considered: one by the World Bank and another by the International Monetary Fund (IMF). These classifications allow for a more nuanced understanding of how the inequality-emissions nexus operates across countries with different levels of economic development and structural characteristics.

World Bank Income Groups

The World Bank classifies economies based on their gross national income (GNI) per capita using the Atlas method. As of 2023, the thresholds are defined as follows: [25].

- **Low-income economies**: GNI per capita of $1,145 or less
- **Lower-middle-income economies**: GNI per capita between $1,146 and $4,515
- **Upper-middle-income economies**: GNI per capita between $4,516 and $14,005
- **High-income economies**: GNI per capita above $14,005

This income-based classification captures differences in productive capacity, consumption behavior, trade integration, and environmental regulation. Panel regressions are estimated separately for each income group to test whether the inequality-emissions-trade relationship varies with development level.

IMF Classification of Economies

The second classification follows the International Monetary Fund's (IMF) World Economic Outlook (WEO) framework.[26]. This divides countries into two broad groups:

- **Advanced Economies**: Includes the G7 countries, Euro Area members, and other high-income industrialized nations.
- **Emerging Market and Developing Economies**: Subdivided into regions such as Emerging Asia, Latin America, Sub-Saharan Africa, Emerging Europe, and the Middle East and Central Asia.

Unlike the World Bank classification, the IMF grouping is not based on strict economic thresholds but rather on historical, institutional, and regional considerations aimed at facilitating comparative macroeconomic analysis. It allows a complementary assessment of structural dynamics across global economic blocs.

Motivation and Use in Analysis

Using both classification systems enables robustness checks and cross-validation of results. The World Bank classification captures discrete economic thresholds that may influence environmental outcomes through affordability constraints, technological access, or policy priorities. The IMF classification, by contrast, provides broader geopolitical and macro-structural divisions that may correlate with institutional quality, industrial complexity, and participation in global trade networks.

Subsequent regressions are stratified by both classification schemes to investigate whether and how the relationship between top income shares, trade interactions, and CO_2 emissions differs across development levels. To do so, all main regression models are re-estimated separately for each World Bank income group (low-income, lower-middle-income, upper-middle-income, and high-income countries), and for the IMF's distinction between advanced and emerging and developing economies.

This stratified approach enables comparison of the elasticities of emissions with respect to inequality and trade across income categories. It also allows for assessing whether carbon emissions are driven by different structural mechanisms in low-income versus high-income contexts, and whether top income groups play a stronger role in shaping emissions in more advanced economies.

All specifications maintain the same controls as the baseline model—trade openness, industrial share of GDP, imports, and interaction terms between income shares and trade/imports. Country and year fixed effects are included, standard errors are clustered at the country level, and population weights are applied consistently.

3.2.7 *Identification Considerations*

While fixed effects help mitigate concerns about omitted variable bias, endogeneity remains a potential issue. Trade flows and emissions may be jointly determined, or there may be unobserved time-varying factors driving both. This study does not implement instrumental variables, and the findings should therefore be interpreted as correlations rather than causal effects. Nonetheless, the robustness and theoretical consistency of the results support their empirical value.

Table 3.2: Summary Statistics of Log-Transformed Variables

Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
log(Top 1% Income Share)	6,721	-1.897	0.405	-3.738	-0.281
log(Top 10% Income Share)	6,721	-0.808	0.246	-1.865	-0.146
log(Top 9% Income Share)	6,721	-1.235	0.207	-2.218	-0.780
log(Trade Openness)	5,602	24.089	15.284	1.843	36.841
log(Imports)	5,602	9.445	8.632	1.092	23.025
log(Industrial Share)	5,503	27.602	13.680	1.497	36.841
log(CO_2 Footprint)	6,721	3.609	1.794	-1.985	9.327
log(CO_2 Footprint Per Capita)	6,721	-12.303	1.127	-17.254	-8.931
log(CO_2 Production)	6,721	3.607	1.864	-2.970	9.459
log(CO_2 Production Per Capita)	6,721	0.582	1.701	-5.371	4.246
log(CO_2 Imports)	3,211	-0.270	1.815	-8.690	4.723

Note: All variables are log-transformed. Based on a balanced panel of 160 countries, 1980–2019.

Table 3.2 provides descriptive statistics for the log-transformed variables used in the main regression models. These summary measures help illustrate the variation in key variables across countries and time.

Chapter 4

Results and Discussion

4.1 Regression Results and Interpretation

In this section, we present the results of our baseline regression. The dependent variables are the logs of CO_2 footprint consumption-based emission, CO_2 footprint per capita, CO_2 production-based emission, and CO_2 production per capita. The regressions span 160 countries from 1980 to 2019 and include fixed effects for country and year.

4.1.1 *CO_2 Consumption Footprint – All Countries*

The regression results indicate a significant positive association between the top 9% income share and CO_2 footprint, suggesting that greater income concentration among the upper decile is associated with higher national consumption-based emissions. The coefficient for the top 1% income share is positive but not statistically significant on its own.

Trade openness is negatively associated with CO_2 footprint, and this effect becomes more pronounced when interacted with top income shares. The negative interaction terms imply that in countries with higher income inequality, trade tends to mitigate domestic emissions—possibly due to offshoring of carbon-intensive production.

The interaction between top 1% income share and imports is significantly positive, supporting the hypothesis that elite consumption is more emission-intensive and globally outsourced. The industrial share of GDP and imports on their own are not statistically significant in this model.

4.1.2 *CO_2 Consumption Footprint Per Capita – All Countries*

The per capita results mirror those of the total CO_2 footprint. The top 9% income share again exhibits a positive and significant effect, reinforcing the role of upper-decile income concentration in increasing per capita emissions.

Trade openness continues to show a negative association with per capita emissions, and its interactions with both top 1% and top 9% shares remain significantly negative. The interaction between top 1% and imports is again positive and statistically significant, highlighting the emissions embedded in imports linked to elite consumption.

4.1.3 *Territorial CO_2 Emissions – All Countries*

The top 9% income share has a strong and statistically significant positive effect on production-based emissions. Trade openness is negatively associated with territorial emissions, and this effect intensifies in more unequal countries, as indicated by the negative interaction terms.

The interaction between top 1% income and imports remains positive and significant, suggesting a strong link between elite inequality and imported emissions. The direct effects of industrial share and imports are not statistically significant.

4.1.4 *Territorial CO_2 Emissions Per Capita – All Countries*

In this specification, the top 9% income share continues to show a strong and significant positive effect. Trade openness has a negative and significant impact on per capita production emissions, and its interaction with top 1% remains significantly negative.

The interaction of top 1% with imports also remains significantly positive, further reinforcing the global outsourcing of emissions by elites. Other coefficients, including industrial share and imports, are not statistically significant in this model.

Table 4.1: Summary of Main Regression Results – All Countries (Elasticities)

Variable	**CO_2 FP**	**CO_2 FP/Capita**	**Territorial CO_2**	**Territorial CO_2/Capita**
log(Top1)	0.260	0.363	0.267	0.282
log(Top9)	**0.689****	**0.707****	**0.947*****	**1.246*****
log(Trade)	**-0.164*****	**-0.136*****	**-0.159*****	**-0.136****
log(Top1) $\times$ log(Trade)	**-0.045*****	**-0.036*****	**-0.045*****	**-0.039*****
log(Top9) $\times$ log(Trade)	**-0.056*****	**-0.040****	**-0.055*****	-0.037
log(Industry)	0.022	0.010	0.024	0.024
log(Imports)	0.096	0.039	0.085	0.038
log(Top1) $\times$ log(Imports)	**0.050*****	**0.035*****	**0.047*****	**0.041****
log(Top9) $\times$ log(Imports)	0.032	0.011	0.018	-0.026

Notes: Bold values indicate statistical significance. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.

4.1.5 *CO_2 Imports and Income Groups – Reduced-Form Estimates*

The reduced-form regressions of log CO_2 imports on income shares reveal that top 1% and top 10% income shares are significantly and positively associated with higher CO_2 imports. In contrast, the middle 40% and bottom 50% shares are significantly negatively associated with CO_2 imports.

These results support the view that affluent groups disproportionately drive emissions through consumption of imported goods, while more equitable income distributions are linked to lower imported emissions.

4.1.6 *CO_2 Imports and Income Groups – Reduced-Form Estimates*

To further investigate the role of income inequality in shaping international environmental externalities, we estimate separate reduced-form regressions of log CO_2 imports on the income share of each group independently. These regressions isolate the correlation between group-specific income concentration and the emissions embedded in imported goods and services, controlling for country and year fixed effects and applying population weights.

The results suggest that the top 1% and top 10% income shares are strongly and positively associated with CO_2 imports Table 4.2. This supports the hypothesis that higher concentration of income at the top is linked to increased outsourcing of emissions through international trade. Affluent elites, by virtue of their carbon-intensive consumption patterns, drive up the demand for goods whose emissions are produced elsewhere.

Table 4.2: CO_2 Imports and Income Groups (Reduced-Form Regressions)

Income Group	**Coefficient**	**Std. Error**	**Significance**
Top 1%	0.901	0.245	***
Top 9%	-1.229	0.789	
Top 10%	1.555	0.690	**
Middle 40%	-2.236	0.541	***
Bottom 50%	-1.074	0.343	***

In contrast, the income shares of the middle 40% and bottom 50% are negatively associated with CO_2 imports. These effects are both statistically significant and economically meaningful, indicating that more equitable income distributions are associated with lower imported emissions. One possible interpretation is that mass consumption by middle and lower income groups tends to be more localized and less dependent on emission-intensive global supply chains.

The coefficient on the top 9% is negative but not statistically significant. But together, these results reveal a clear asymmetry: imported emissions are disproportionately driven by consumption patterns at the top of the income distribution. As such, global carbon inequality is not only a matter of how much is consumed, but where the emissions occur — with high-income individuals in wealthier countries effectively outsourcing their environmental impact.

4.1.7 *Summary of Results*

The baseline regressions for all countries reveal a consistent and theoretically coherent pattern linking income inequality, trade, and environmental externalities. Across all four core models—CO_2 footprint (total and per capita) and territorial emissions (total and per capita)—the income share of the top 9% emerges as a robust and significant predictor of higher emissions. This effect is particularly strong for production-based emissions, with elasticities exceeding 0.9 for both total and per capita CO_2 output.

While the top 1% income share does not exhibit a consistently significant direct effect on emissions, it plays a meaningful role through interaction terms. Specifically, interaction terms between the top 1% share and trade openness or imports are significant in all four models, suggesting that the environmental influence of elite income operates primarily through global trade dynamics.

Trade openness is negatively associated with emissions in all specifications. This implies that countries more integrated into global trade networks tend to have lower domestic and consumption-based emissions, a pattern consistent with the hypothesis of emissions outsourcing. However, the interaction terms indicate that this effect is conditional on inequality: in more unequal countries, the reduction in domestic emissions associated with trade is amplified—potentially due to greater offshoring of carbon-intensive production by elites.

The role of imports is more nuanced. While the total import coefficient is not always statistically significant, the interaction between top 1% income and imports is consistently positive and significant. This reinforces the interpretation that high-income consumers in unequal societies are more likely to drive emissions that are embedded in internationally sourced goods.

The reduced-form regressions on CO_2 imports by income group further support this conclusion. A one percent increase in the top 1% income share is associated with a nearly 0.9% increase in CO_2 imports. In contrast, greater income shares for the middle 40% and bottom 50% are associated with significantly lower imported emissions. These findings underscore the regressive structure of environmental externalities: emissions are not just a function of national economic size, but of how income is distributed within countries.

Overall, the results suggest that income inequality—especially at the very top—shapes the geography and scale of emissions in the global economy. Elites in unequal countries exert outsized influence on global emissions not only through domestic production but by shifting environmental burdens abroad via trade. This highlights the importance of considering both distributional and transnational dimensions of environmental policy.

4.2 Results by World Bank Income Classification

To examine whether the relationship between income inequality, trade, and CO_2 emissions varies across development levels, we re-estimate the baseline regression separately for each income group defined by the World Bank: low income, lower-middle income, upper-middle income, and high income.

4.2.1 ***CO_2 Consumption Footprint by Country Income Classification***

Low-Income Countries

The top 1% income share has a significant negative effect on CO_2 footprint, contrary to expectations. Trade openness also reduces emissions, and the interaction of top 1% with trade remains significantly negative. This may reflect limited elite access to global carbon-intensive consumption.

Lower-Middle Income Countries

The top 1% income share has a positive and significant effect on emissions, consistent with the global results. However, trade interactions are insignificant, suggesting that in this group, inequality drives emissions directly through domestic consumption more than through trade mechanisms.

Upper-Middle Income Countries

The top 9% income share is strongly associated with increased emissions, whereas the top 1% has no significant effect. The interaction terms are insignificant, which may reflect mixed development patterns in this heterogeneous group.

High-Income Countries

The top 1% income share is positively and significantly associated with higher CO_2 footprints, while the top 9% has a negative effect (marginally significant at 10%). In particular, the interaction between the top 1% and trade is significantly negative, indicating that in more open economies to trade, the carbon intensity of elite consumption is mitigated. The import interaction with top 1% is also positive and significant, suggesting that high-income elites increase emissions through consumption of imported goods.

Table 4.3: Regression Results by World Bank Income Classification – CO_2 Consumption Footprint

Variable	**Low Income**	**Lower Middle Income**	**Upper Middle Income**	**High Income**
log(Top1)	**-0.396*****	**0.189*****	0.007	**0.361*****
log(Top9)	-0.173	0.061	**1.417*****	-1.819*
log(Trade)	**-0.066****	-0.042	0.057	-0.006
log(Top1) × log(Trade)	**-0.038*****	-0.001	-0.016	**-0.028*****
log(Top9) × log(Trade)	0.008	-0.000	0.056	0.038
log(Industry)	-0.015	0.006	**0.032****	0.011
log(Imports)	0.010	0.019	-0.089	-0.031
log(Top1) × log(Imports)	**0.055*****	-0.003	0.053	**0.017*****
log(Top9) × log(Imports)	-0.056	-0.014	-0.113	-0.004

Notes: Bold values indicate statistical significance. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.

4.2.2 *CO_2 Consumption Footprint Per Capita by Country Income Classification*

Low-Income Countries

Unexpectedly, the top income share 1% is negatively associated with per capita emissions ($\beta \approx -0.396^{***}$), potentially reflecting low levels of recorded elite consumption or data volatility in these countries. However, the interaction with trade is significantly negative ($\beta \approx -0.038^{***}$), suggesting that trade may amplify the emissions-suppressing effects of inequality.

The top 1% $\times$ imports term remains positive and significant ($\beta \approx 0.055^{***}$), highlighting the role of imported consumption in driving elite carbon footprints even in poor countries.

Lower-Middle-Income Countries

The top income share 1% has a positive and significant effect on per capita emissions ($\beta \approx 0.189^{***}$), while the top 9% is not significant. However, unlike in other groups, none of the interaction terms are statistically significant. This implies that inequality directly drives emissions in these economies without strong mediation through trade or imports.

Upper-Middle-Income Countries

In upper-middle-income countries, the top 9% income share has a large and significant positive effect ($\beta \approx 1.417^{***}$), while the top 1% does not have a significant influence. This suggests that broader elite classes, rather than just the top percentile, drive emissions in these transitioning economies.

None of the interaction terms with trade or imports are significant, implying weaker moderating effects of trade openness on the inequality-emissions relationship in these contexts. The industrial share of GDP is positively associated with emissions, reflecting the intensity of carbon in growth in these economies.

High-Income Countries

The highest income share 1% is positively and significantly associated with CO_2 footprint per capita ($\beta \approx 0.361^{***}$), indicating that the increasing concentration of income at the top increases the average emissions. In contrast, the highest income share 9% has a negative association ($\beta \approx -1.82^{*}$), suggesting that larger income shares of elites may not increase emissions in the same way.

In particular, the interaction term between the top 1% and trade openness is significantly negative ($\beta \approx -0.028^{***}$), consistent with the interpretation that higher trade integration in unequal societies reduces domestic emissions by offshoring production. The top 1% $\times$ imports term is also significantly positive ($\beta \approx 0.017^{***}$), which reinforces that high-income elites contribute to emissions through carbon-intensive imports.

Table 4.4: Regression Results by World Bank Income Classification – CO_2 Footprint Per Capita

Variable	**Low Income**	**Lower Middle Income**	**Upper Middle Income**	**High Income**
log(Top1)	**-0.396*****	**0.189*****	0.007	**0.361*****
log(Top9)	-0.173	0.061	**1.417*****	-1.819*
log(Trade)	**-0.066****	-0.042	0.057	-0.006
log(Top1) × log(Trade)	**-0.038*****	-0.001	-0.016	**-0.028*****
log(Top9) × log(Trade)	0.008	-0.000	0.056	0.038
log(Industry)	-0.015	0.006	**0.032****	0.011
log(Imports)	0.010	0.019	-0.089	-0.031
log(Top1) × log(Imports)	**0.055*****	-0.003	0.053	**0.017*****
log(Top9) × log(Imports)	-0.056	-0.014	-0.113	-0.004

Notes: Bold values indicate statistical significance. * p<0.1, ** p<0.05, *** p<0.01.

4.2.3 *CO_2 Production Emissions by Country Income Classification*

Low-Income Countries

In low-income countries, the top 1% income share is negatively and significantly associated with territorial CO_2 emissions ($\beta \approx -0.276^{**}$), suggesting that greater income concentration at the very top is linked to lower domestic production emissions. This may reflect elite disengagement from local industrial activity or a reliance on imported carbon-intensive goods, as further indicated by the positive and significant interaction with imports ($\beta \approx 0.068^{***}$), meaning the top 1%'s emissions may be outsourced via trade.

The top 9% share is not statistically significant, and the trade-related interaction terms are also mostly insignificant—except for the top 1% $\times$ trade term, which is significantly negative ($\beta \approx -0.038^{***}$). This suggests that emissions associated with elite consumption in low-income countries are shaped more by import and trade patterns than by direct domestic production.

Lower-Middle-Income Countries

In lower-middle-income countries, the top 9% income share is positively and significantly associated with territorial CO_2 emissions ($\beta \approx 0.373^{***}$), while the top 1% is not statistically significant. This indicates that the broader upper-income segment, rather than the very top, is more closely tied to rising emissions in these countries—possibly due to growing domestic demand for industrial or energy-intensive goods.

None of the interaction terms in this group is statistically significant, implying that trade and imports do not play a moderating role in how inequality shapes emissions in these economies.

Upper-Middle-Income Countries

In upper-middle-income countries, the top 9% income share is again strongly and positively associated with emissions ($\beta \approx 1.657^{***}$), reinforcing the idea that elite-driven domestic consumption or ownership structures drive pollution. However, the top 1% share remains not significant, suggesting emissions are more broadly distributed among the wealthier segments rather than hyper-concentrated at the very top.

Interestingly, no interaction terms are statistically significant, indicating that trade and import channels may not mediate the relationship between income concentration and emissions in these relatively industrialized settings.

High-Income Countries

In high-income countries, the top 1% income share is positively and highly significant ($\beta \approx 0.437^{***}$), suggesting that the very rich have a notable role in increasing territorial emissions—likely due to ownership of production capital or high domestic consumption footprints.

Conversely, the top 9% income share is significantly negative ($\beta \approx -1.962^{**}$), indicating a complex internal elite structure, where middle-to-upper elites might outsource emissions or shift their demand toward cleaner sectors.

The top 1% $\times$ trade interaction is negative and significant ($\beta \approx -0.027^{***}$), suggesting that rising income at the very top may reduce domestic emissions by increasing reliance on imported, emission-intensive goods. Meanwhile, the top 9% $\times$ trade interaction is positive and significant ($\beta \approx 0.053^{**}$), pointing to a possible trade-emissions link through export-driven industries tied to this broader elite class.

Table 4.5: Regression Results by World Bank Income Classification – Territorial CO_2 Emissions

Variable	**Low Income**	**Lower Middle Income**	**Upper Middle Income**	**High Income**
log(Top1)	**-0.276****	0.097	0.074	**0.437*****
log(Top9)	0.108	**0.373*****	**1.657*****	**-1.962****
log(Trade)	**-0.082*****	-0.062	0.101	0.018
log(Top1) × log(Trade)	**-0.038*****	0.008	-0.007	**-0.027*****
log(Top9) × log(Trade)	-0.015	-0.039	0.078	**0.053****
log(Industry)	0.001	0.003	0.032	0.009
log(Imports)	0.088	0.041	-0.138	-0.036
log(Top1) × log(Imports)	**0.068*****	-0.018	0.037	0.010
log(Top9) × log(Imports)	-0.014	0.035	-0.154	-0.022

Notes: Bold values indicate statistical significance. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.

4.2.4 *CO_2 Production Emissions Per Capita by Country Income Classification*

Low-Income Countries

In low-income economies, neither the top 1% nor the top 9% income shares are significantly associated with per capita territorial emissions. However, two interaction terms are significant. The top 1% × trade term is significantly negative ($\beta \approx -0.020^{*}$), suggesting that trade openness reduces the emissions impact of top income concentration. More notably, the top 9% × imports interaction is negative and significant ($\beta \approx -0.154^{**}$), implying that wealthier segments in poor countries may outsource their emissions through imported goods, limiting their contribution to domestic production-based emissions.

Other variables—including top income shares, trade, and industry share—are statistically insignificant in this context, indicating that the relationship between inequality and emissions is more likely channeled through trade-related mechanisms rather than direct domestic production.

Lower-Middle-Income Countries

In lower-middle-income countries, the top 9% income share is positively and significantly associated with per capita emissions ($\beta \approx 0.609^{**}$), while the top 1% share remains statistically insignificant. The interaction between the top 9% and trade openness is also significant and positive ($\beta \approx 0.105^{**}$), suggesting that growing trade magnifies the emissions effect of upper-class income in these emerging economies.

Import-related interactions for the top 9% are significantly negative ($\beta \approx -0.205^{**}$), indicating that imported goods may act as substitutes for domestic production, partially offsetting the emissions impact of inequality.

Upper-Middle-Income Countries

In upper-middle-income countries, the top 9% income share is strongly and positively associated with per capita emissions ($\beta \approx 2.172^{***}$), while the top 1% share remains insignificant. This reinforces the idea that inequality's effect on emissions in these economies is driven by broader upper-income groups rather than extreme elites.

None of the interaction terms—including those with trade and imports—are statistically significant. The industrial share has a weakly positive but non-significant effect, suggesting limited moderating roles of sectoral composition or external trade in this group.

High-Income Countries

In high-income countries, the top 1% income share is positively and significantly associated with per capita emissions ($\beta \approx 0.426^{**}$), indicating that the wealthiest individuals continue to play a disproportionate role in driving domestic carbon output. By contrast, the top 9% income share is strongly and significantly negative ($\beta \approx -2.280^{***}$), suggesting a stratified elite class where middle-to-upper elites may rely more heavily on services or imported consumption, reducing their domestic production footprint.

Interaction terms reinforce these findings. The top 1% $\times$ trade term is negative and significant ($\beta \approx -0.024^{***}$), implying that openness to trade reduces emissions linked to the very top. Meanwhile, the top 9% $\times$ trade term is positive and significant ($\beta \approx 0.067^{***}$), possibly capturing domestic emissions embedded in export-linked consumption or production among the broader elite. Industrial activity and import-related interactions show modest but significant effects.

Table 4.6: Regression Results by World Bank Income Classification – Per Capita Territorial CO_2 Emissions

Variable	**Low Income**	**Lower Middle Income**	**Upper Middle Income**	**High Income**
log(Top1)	-0.002	0.108	0.007	**0.426****
log(Top9)	1.001	**0.609****	**2.172*****	**-2.280*****
log(Trade)	-0.026	0.086*	0.105	0.039
log(Top1) × log(Trade)	**-0.020***	0.005	-0.010	**-0.024*****
log(Top9) × log(Trade)	0.040	**0.105****	0.084	**0.067*****
log(Industry)	0.013	0.006	0.031	**0.012****
log(Imports)	-0.142	**-0.163****	-0.179	**-0.045***
log(Top1) × log(Imports)	0.016	-0.004	0.047	**0.011****
log(Top9) × log(Imports)	**-0.154****	**-0.205****	-0.199	**-0.030***

Notes: Bold values indicate statistical significance. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.

4.2.5 *CO_2 Imports and Top Income Shares by Income Groups Classification*

To further assess the role of top income groups in shaping cross-border environmental externalities, we regress CO_2 imports on top income shares for each World Bank income group. The dependent variable is the logarithm of CO_2 imports per country-year, and each model includes country and year fixed effects with population weights and clustered standard errors.

Top 1% Income Share

- **Low-income countries:** The top 1% income share has a positive and statistically significant effect on CO_2 imports ($\beta = 0.90$***). This suggests that higher income concentration at the top is associated with greater environmental externalization through imports in low-income settings.
- **Upper-middle-income countries:** A similarly significant and positive relationship is found ($\beta = 0.54$***), indicating that elite income concentration contributes to imported emissions.
- **High-income and lower-middle-income countries:** The coefficients are positive but not statistically significant. In high-income countries, this may reflect internalization of emissions via domestic regulation; in lower-middle-income countries, it may reflect weaker trade capacity or data noise.

Top 9% Income Share

- **Low-income countries:** A significant negative relationship is also observed ($\beta = -1.20$***), which may reflect structural dependencies that limit emissions outsourcing despite rising inequality.
- **Lower- and upper-middle-income countries:** Coefficients are positive but statistically insignificant, with large standard errors, reflecting substantial uncertainty and potential heterogeneity in emissions-importing behavior among middle-income elites.
- **High-income countries:** Interestingly, the top 9% share is negatively associated with CO_2 imports ($\beta = -2.83$***). This may reflect more efficient consumption patterns or stronger climate regulation among upper-income segments.

Top 10% Income Share

- **Lower-middle-income countries:** The coefficient is large and marginally significant ($\beta = 7.29$*), suggesting a potential emissions outsourcing behavior by the upper decile.

Taken together, the results show heterogeneous patterns of association between top income shares and CO_2 imports. The top 1% income share is positively associated with imported emissions in lower-income and upper-middle-income countries, indicating a role for elite consumption in driving cross-border environmental burdens. In contrast, the top 9% income share shows a strong negative effect in high- and low-income groups, suggesting more complex or offsetting dynamics.

Table 4.7: Effect of Top Income Shares on CO_2 Imports by World Bank Income Group

	Low Income	**Lower Middle Income**	**Upper Middle Income**	**High Income**
Top 1% Income Share	**0.905*** **	2.516	**0.540*** **	0.274
	(0.314)	(1.926)	(0.199)	(0.338)
	[0.010]	[0.200]	[0.011]	[0.421]
Top 9% Income Share	**−1.196** **	5.365	−0.473	**−2.832*** **
	(0.498)	(3.582)	(1.238)	(0.945)
	[0.027]	[0.143]	[0.705]	[0.004]
Top 10% Income Share	1.495	**7.290* **	1.777	−0.683
	(1.586)	(3.931)	(1.144)	(0.711)
	[0.358]	[0.072]	[0.131]	[0.341]

Notes: Standard errors in parentheses. p-values in brackets. * p<0.1, ** p<0.05, *** p<0.01.

Notes: Robust standard errors in parentheses. P-values in brackets.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. All models include country and year fixed effects, clustered SEs by country.

4.3 Results by IMF Economies Classification

Advanced Economies

This section presents the regression results for the group of countries classified as Advanced Economies by the IMF. The results are summarized as follows:

- **Top 1% Income Share:** Across all four main emissions metrics—CO_2 footprint (total and per capita) and CO_2 production (total and per capita)—the coefficient on the top 1% income share is positive and statistically significant. This suggests that in advanced economies, a higher concentration of income among the top 1% is associated with increased emissions, both through production and consumption channels. However, the top 1% is not significantly associated with CO_2 imports, indicating that their emissions are primarily domestic rather than offshored.

- **Top 9% Income Share:** In contrast, the top 9% income share is significantly negatively associated with total and per capita CO_2 footprint and production. This negative relationship may reflect a compositional shift where emissions related to the upper-middle class are declining or being substituted by those of the top 1%. Interestingly, the top 9% share also shows a strong negative effect on CO_2 imports, implying that economies with more concentrated upper-class income may outsource less of their emissions via trade.

- **Trade Interaction Effects:** The interaction term between the top 1% share and trade openness is consistently negative and highly significant across all specifications. This result indicates that in countries more integrated into global trade, the marginal effect of income concentration at the very top on emissions is attenuated. In contrast, the interaction term for the top 9% and trade is positive and significant, especially for per capita metrics, suggesting that trade magnifies the emission effects for the broader upper-income group.
- **CO_2 Imports Regressions:** While the top 1% income share does not show a statistically significant effect on CO_2 imports, the top 9% share is significantly negative. This finding reinforces the notion that more unequal income distribution at the upper levels within advanced economies is linked to a lower reliance on imported emissions.
- **Control Variables:** Other controls such as trade openness and industrial share are mostly insignificant. The coefficient on imports is not significant in most models, although it does slightly increase in magnitude for per capita models.

Overall, the evidence from advanced economies supports the hypothesis that the top 1% income share is a significant driver of CO_2 emissions, with its effect partially mitigated by trade. In contrast, the top 9% share shows an inverse relationship with emissions, potentially pointing to nuanced differences in consumption patterns and trade behavior between the very rich and the broader affluent class.

Table 4.8: Effect of Top Income Shares on CO_2 Emissions in Advanced Economies (IMF)

	CO_2 Footprint		CO_2 Production		CO_2 Imports	
	Total	Per Capita	Total	Per Capita	Top 1%	Top 9%
log_top1	0.445***	0.412***	0.555***	0.538***	0.431	
	(0.076)	(0.080)	(0.088)	(0.097)	(0.315)	
log_top9	-2.056**	-2.204**	-2.268**	-2.507***		-3.334***
	(1.024)	(0.810)	(0.851)	(0.721)		(0.996)
log_trade1	0.018	0.038	0.041	0.066*		
	(0.039)	(0.029)	(0.033)	(0.027)		
logtop1_trade	-0.023***	-0.021***	-0.024***	-0.022***		
	(0.005)	(0.005)	(0.006)	(0.006)		
logtop9_trade	0.048*	0.059**	0.064**	0.077***		
	(0.027)	(0.020)	(0.019)	(0.019)		
log_imp	0.073	0.111	0.052	0.077		
	(0.088)	(0.112)	(0.090)	(0.103)		
logtop1_imp	0.025**	0.031**	0.015	0.018		
	(0.011)	(0.015)	(0.012)	(0.018)		
logtop9_imp	0.047	0.012	0.030	0.008		
	(0.052)	(0.053)	(0.056)	(0.066)		
Constant	5.078***	-13.515***	4.709***	-0.375	1.49**	-4.14***
	(1.590)	(1.270)	(1.357)	(1.155)	(0.67)	(1.41)
Observations	2.76e+10	2.76e+10	2.76e+10	2.76e+10	3.11e+10	3.11e+10
Countries	37	37	37	37	35	35
R-squared	0.995	0.933	0.995	0.943	0.734	0.761

Notes: Robust standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Emerging and Developing Economies

This section presents regression estimates for countries classified as Emerging and Developing Economies by the IMF.

- **Top 1% Income Share:** The coefficient on the top 1% income share is positive across all models but statistically significant only in the CO_2 imports regression. Specifically, a 1% increase in top 1% income share is associated with a statistically significant 1% increase in CO_2 imports, suggesting that elites in developing economies increasingly outsource emissions via trade. However, the effect on total and per capita CO_2 footprint and production is positive but not statistically significant at the 5% level.

- **Top 9% Income Share:** The top 9% income share is consistently positively associated with territorial and footprint emissions, and the coefficient on CO_2 production per capita is both large and statistically significant. A 1% increase in the top 9% share corresponds to a 1.2% increase in per capita production emissions. This indicates that income concentration in the broader upper class is a key driver of domestic production emissions in these economies. However, the relationship with CO_2 imports is not significant, suggesting that these emissions are mostly domestic.

- **Trade Interactions:** The interaction between the top 1% and trade openness is significantly negative across all emission outcomes (except CO_2 imports). This indicates that in more trade-integrated economies, the emission impact of the top 1% is reduced, possibly due to offshoring or cleaner production enabled by trade liberalization. Meanwhile, the interaction between the top 9% and trade openness is mostly insignificant.

- **CO_2 Imports Regressions:** The regression using the top 1% share as the sole regressor shows a statistically significant positive association with CO_2 imports. In contrast, the top 9% and top 10% coefficients are negative but not significant (except marginally for top 10%). This implies that CO_2 import responsibility is concentrated among the very rich rather than the broader affluent class in emerging economies.

- **Controls:** Trade openness shows a statistically significant and negative effect on CO_2 emissions, particularly for total and per capita footprint and production. Industrial share and total imports are not statistically significant across the models, while the interaction of imports with the top 9% is negative and significant only in the per capita production regression, indicating some offshoring behavior.

To summarize, results for emerging and developing countries highlight that both the top 1% and the broader top 9% income groups contribute to rising CO_2 emissions, but through different channels. The top 1% are more strongly associated with offshoring (imports), while the top 9% appear to drive domestic production-related emissions. The mitigating effect of trade on inequality-driven emissions appears less consistent than in advanced economies.

Table 4.9: Effect of Top Income Shares on CO_2 Emissions in Emerging and Developing Economies (IMF)

	CO_2 Footprint		CO_2 Production		CO_2 Imports	
	Total	Per Capita	Total	Per Capita	Top 1%	Top 9%
log_top1	0.246	0.359	0.251	0.262	1.004**	
	(0.166)	(0.228)	(0.177)	(0.216)	(0.486)	
log_top9	0.583*	0.633	0.841***	1.201***		-0.552
	(0.343)	(0.415)	(0.277)	(0.415)		(0.795)
log_trade1	-0.080**	-0.071**	-0.086***	0.022		
	(0.032)	(0.031)	(0.031)	(0.056)		
logtop1_trade	-0.042***	-0.031**	-0.037***	-0.025**		
	(0.013)	(0.012)	(0.013)	(0.011)		
logtop9_trade	0.003	0.003	-0.010	0.070		
	(0.026)	(0.028)	(0.025)	(0.047)		
log_imp	-0.027	-0.056	-0.026	-0.214**		
	(0.071)	(0.076)	(0.077)	(0.106)		
logtop1_imp	0.043	0.026	0.032	0.016		
	(0.025)	(0.022)	(0.027)	(0.023)		
logtop9_imp	-0.061	-0.056	-0.053	-0.199**		
	(0.045)	(0.046)	(0.046)	(0.081)		
Constant	7.719***	-11.044***	8.086***	2.408***	-0.276	-2.644***
	(0.494)	(0.730)	(0.531)	(0.677)	(0.830)	(0.939)
Observations	1.85e+11	1.85e+11	1.85e+11	1.85e+11	2.64e+10	2.64e+10
Countries	123	123	123	123	103	103
R-squared	0.993	0.954	0.994	0.972	0.679	0.671

Notes: Robust standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Chapter 5

Conclusion

This research paper began with a simple yet troubling observation: those responsible for the highest amounts of CO_2 emissions are usually excluded from the consequences of their heavy CO_2 consumption. By gathering a group of theoretical models and empirical evidence, we were able to examine how income inequality within the country interacts with trade patterns to shape the geography and intensity of CO_2 emissions. The results confirm that emissions are not only unequally distributed within country across different income earners, but aslo across different countries and their income earners as well.

Data for income shares and carbon emissions and consumption were collected from the World Inequality Database, combined with trade data from the World Bank Development Indicators Database. We used a log-log panel regression model, with country and year fixed effects, population weighted, and standard errors clustered at the country level inorder to estimate the relationship between income inequality, trade flows, and CO_2 emissions. Our results showed that the top 9% of earners are consistently associated with higher levels of both territorial and consumption-based emissions. More strikingly, the top 1% play an outsized role when it comes to imported emissions, indicating a strong link between elite consumption and the global outsourcing of pollution. These effects persist across income groups, development levels, and trade openness, but they are most pronounced in high income countries and advanced economies.

The theoretical framework developed in this paper explains these empirical patterns by combining the logic of Pigouvian externalities with the realities of global inequality and trade. In unequal societies, those at the top can consume more without internalizing the environmental costs—particularly when trade allows them to shift production, and therefore emissions, elsewhere. This dynamic results in what we call inequality-driven, trade-facilitated externalities: a structural feature of the global economy in which the affluent export not only goods but also environmental damage.

The findings carry important policy implications. Efforts to reduce emissions must be attentive not only to where emissions are generated, but to who is driving them and how. Carbon taxes, for instance, may need to be paired with redistributive policies to avoid regressive effects. Trade agreements should incorporate environmental safeguards that account for carbon outsourcing. And any serious attempt at climate mitigation must consider the role of elite overconsumption—an often overlooked, yet critical, driver of global emissions.

Perhaps most importantly, this research underscores that climate change is not simply an environmental or technological problem—it is a distributional one. Addressing it will require confronting structural inequalities that allow some to consume without consequence, while others bear the costs. In that sense, the path to climate justice runs through the terrain of economic justice. What we emit, where we emit it, and who pays the price are questions that can no longer be separated.

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