GreenPaths

EUROPEAN KNOWLEDGE HUB ON
JUST TRANSITION PATHWAYS

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### Authors
Thomas Kopp (Justus-Liebig-University Giessen), Syeda Aimen Abbas (Justus-Liebig-University Giessen)

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# Introduction

## Abstract

This case study examines the distributional and environmental impacts of the European Union's green transition, addressing the gap in research that jointly considers social inequality and emission offshoring. While much of the literature on carbon leakage focuses on the EU Emission Trading Scheme (ETS) with inconclusive results, we employ the OECD's Climate Actions and Policies Measurement Framework (CAPMF) and its Environmental Policy Stringency Index (EPSI), which captures over 100 policy variables, to analyse the broader effects of environmental policy. The central research question asks whether stricter climate policies in Europe simultaneously (a) exacerbate income inequality at home and (b) shift emissions abroad. The analysis relies on panel data from 1990–2022 for inequality, unemployment, social expenditures, and trade data from 2016–2023 to derive imported emissions. The results suggest that policy stringency raises pre-tax and post-tax inequality but not disposable inequality, highlighting the protective role of welfare states in the Just Transition. At the same time, stricter environmental policies increase imported emissions from the Global South to the EU. The case study provides a joint view on domestic and global dimensions of the Just Transition debate, revealing undesired side effects of the existing policies.

## Keywords

Environmental Policy Stringency Index (EPSI); Global south; environmental tax; Fully Modified Ordinary Least Square (FMOLS).

# 1 Overview

In the effort to safeguard the integrity of the Earth's biosphere, Europe has introduced an ambitious set of measures to reduce its contribution to climate change. These are largely bundled under the European Green Deal (EGD), which commits the EU to a 55 % reduction in greenhouse gas emissions by 2030 and to achieving climate neutrality by 2050 (European Commission, 2019). The Green Deal aspires not only to ecological sustainability but also to economic viability and social fairness. To support this Just Transition, the EU has allocated around €55 billion to mitigate socio-economic impacts in the regions most affected by decarbonisation. Yet, evidence increasingly suggests that the transition may reproduce or even intensify social inequalities, with vulnerable groups bearing disproportionate costs (Baran et al., 2020; Chateau et al., 2018; Wang et al., 2016).

Across the globe, the number of climate-related laws has multiplied, from 72 in 1997 to over 5000 in 2017 (Nachmany & Setzer, 2018). Within Europe, this expansion has taken the form of market-based instruments such as carbon taxes, the EU Emissions Trading System, and fuel excise duties, alongside regulatory measures and renewable-energy incentives (Nachtigall et al., 2022). These instruments aim to accelerate the transition to a low-carbon economy but can also generate unintended distributional effects. Empirical evidence shows that environmental taxation and rising energy prices may disproportionately affect low-income households and regions heavily dependent on fossils (Haug 2018). This makes it crucial to examine whether the social dimension of the Green Deal and its objective of fairness are being achieved.

This case study therefore investigates both the social and environmental consequences of environmental policy stringency in the European Union. The first part analyses how stricter environmental policies influence income inequality within European countries, capturing whether the transition burdens lower-income groups more heavily and how welfare systems mitigate these effects. The second part extends this perspective beyond Europe, exploring whether the same policies contribute to carbon leakage, which refers to the offshoring of emissions through trade with less regulated economies in the Global South (The terms emission offshoring and carbon leakage are used interchangeably in this report). Together, these two dimensions reveal the paradox of Europe's green transition: policies designed to ensure fairness and sustainability at home may, under certain conditions, shift environmental and economic pressures elsewhere.

This dual focus aligns closely with the GreenPaths project's broader aim of understanding how green transition policies shape both environmental sustainability and social wellbeing. By linking environmental policies with both, domestic inequality outcomes and international emission flows, the study highlights how the social and environmental dimensions of Europe's transition are deeply interconnected. Stricter climate policies can advance decarbonisation but also redistribute costs across income groups and national borders. The findings therefore emphasise the importance of policy coherence, ensuring that environmental ambition is matched by social protection at home and by fair, cooperative mechanisms in global governance. In doing so, the case contributes to a wider understanding of how the green transition can deliver not only on climate objectives, but also on its promise of a just transition, in Europe and globally.

# 2 Research questions

The central research questions of this study are whether stricter environmental policies in Europe simultaneously a) exacerbate economic inequality at home and b) shift emissions abroad. Using the OECD's Climate Actions and Policies Measurement Framework (CAPMF) the study assesses the following questions:

i. Is stringent environmental legislation associated with greater income inequality within Europe?
ii. Is stringent environmental legislation associated with higher imported emissions from the Global South?

Together, the two dimensions highlight the paradox of Europe's Just Transition: while intended to be fair and inclusive, such policies risk placing disproportionate burdens on economically vulnerable groups in Europe and climate protection efforts abroad.

# 3 Methods

This case study applies panel data econometrics for the two analytical dimensions. The key explaining variable of these analyses, the Environmental Policy Stringency Index (EPSI) taken from OECD's CAPMF, is an index within the range from 0–10 which covers 130 climate mitigation policy variables, including market and non-market-based instruments. It is the only validated database providing consistent, harmonised, long-term cross-country data on policy stringency (Nachtigall et al., 2022). The database provides indices for sectoral, cross-sectoral, and international policies, which are then combined to create the aggregate EPSI. Since this paper is concerned with the impact of domestic (within Europe) environmental policy adoption and stringency, the EPSI's subindex that captures international policies is excluded from this analysis. Out of the total 130 policies in the framework, aggregated into 56 policies of which 36 are sectoral policies and 12 are cross-sectoral policies (Nachtigall et al., 2022). Using this, a weighted combined average was calculated to create the respective domestic EPSI of the countries in both analyses.

## Domestic analysis

The objective of the first analysis is to assess the effect of environmental policy stringency (EPSI) on income inequality (Gini). The empirical model is given by the following equation:

$$Gini_{it} = \alpha + \beta_1 \, ln\_EPSI_{it} + \beta_2 \, ln\_GDP_{it} + \beta_3 \, ln\_unemp_{it} + \beta_4 \, ln\_SocX_{it} + \gamma_i + \lambda_t + \varepsilon_{it} \quad (1)$$

where *ln GDP* represents the natural log of GDP p.c., *ln unemp* is the log of unemployment percentage, and *ln SocX* is the log of public social expenditure, which is percentage of GDP. $\gamma_i$ and $\lambda_t$ are country- and time-fixed effects, respectively. The natural logarithm was taken so that the coefficients in the estimation results can be discussed in terms of elasticities.

The econometric estimation relies on a balanced panel data set, from 1990 to 2022. It focuses on a core group of twenty EU and European Free Trade Association (EFTA) economies (EU/EFTA membership is defined according to current status. For countries that became independent or joined the EU/EFTA after 1990 (e.g., Czechia, Slovakia, Slovenia, Hungary), harmonised historical national accounts allow us to construct a balanced panel beginning in 1990) with long-run, high-quality data on income distribution and social expenditure. This includes both Western and early Central-Eastern member states such as Czech Republic, Hungary, Poland, Slovakia, and Slovenia (Complete list of countries: Austria, Belgium, Czechia, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Netherlands, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, United Kingdom). This sampler represents countries with the most complete series in the inequality data, relatively similar welfare structures, and more stable and institutionally mature welfare systems (Korzeniowska, 2021; Gubello and Dunne, 2025).

The dependent variable, income inequality, is measured by the Gini coefficient and was sourced from the World Inequality Database (WID) database. This analysis uniquely offers a comprehensive picture of the distributional impact of environmental policies. This is done using three measures of income inequality as dependent variables: the pre-tax national income Gini coefficient, which includes income flows before taxes and transfers but after pensions; the post-tax disposable income Gini coefficient which measures income inequality after taxes and direct government cash transfers; and the post-tax national income Gini coefficient accounting for taxes, direct cash transfers, and in-kind transfers. This analysis shows not only the effect of environmental policies' stringency on income inequality, but also how that influence is mitigated by redistributive mechanisms.

Summary statistics for all variables explaining the empirical analysis are provided in Table 1. The *pre-tax* and *post-tax Gini* have 660 observations, while the disposable income Gini has 613 observations. For the latter, the missing observations are from France.

**Table 1. Summary statistics**

| Variable | Unit | Obs. | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|---|
| Pre-tax Gini | Percentage | 660 | 0.432 | 0.047 | 0.307 | 0.536 |
| Post-tax Gini | Percentage | 660 | 0.289 | 0.0596 | 0.124 | 0.443 |
| Disp. Gini | Percentage | 613 | 0.366 | 0.067 | 0.127 | 0.554 |
| EPSI | Index (0-10) | 660 | 1.931 | 1.528 | 0 | 5.675 |

| | | | | | | |
|---|---|---|---|---|---|---|
| GPDp.c. | Annual % | 656 | 1.765 | 3.365 | -14.639 | 23.443 |
| Unemp | % of total labor force | 640 | 8.413 | 4.367 | 2.015 | 27.686 |
| SocX | % of GPD | 640 | 22.866 | 4.501 | 5.681 | 34.876 |

The WID Manual by Blanchet et al. (2024) provides definitions for each of the inequality measures, as outlined in Table 2. Accounting for endogeneity, cointegration, and slope heterogeneity, this analysis employs the Augmented Mean Group (AMG) estimator for panel timeseries introduced by Eberhardt and Teal (2010).

**Table 2. Definitions of the three measures of the Gini coefficient**

| **Measure** | **Definition** | **Calculation** | **Interpretation** |
|---|---|---|---|
| *Pre-tax National Income Inequality* | Measures income inequality before ac- counting for taxes and government transfers. | Gini coefficient of pre-tax national income (includes labour, capital, and pension income but excludes social insurance benefits). | Indicates baseline in equality before any re-distribution. Higher values imply greater pre-tax income dispar-ities |
| *Disposable Income Inequality* | Measures income in- equality after taxes and direct government cash transfers. | Gini coefficient of post- tax disposable income (pre-tax national in- come minus all taxes plus social assistance benefits in cash). | Shows the impact of direct taxation and social transfers on in-come inequality. A lower value than Pre- tax Gini indicates re-distribution effective- ness. |
| *Post-tax National Income Inequality* | Measures income inequality after taxes, direct cash transfers, and in-kind transfers (e.g., public services like health and educa- tion). | Gini coefficient of post-tax national income (post-tax disposable income plus in-kind transfers such as education and healthcare. | Provides the most comprehensive measure of income distribution, reflecting both monetary and in-kind government redistribution efforts. |

| Measure | Definition | Calculation | Interpretation |
|---|---|---|---|
| | | | |

*Information based on the WID Manual (Blanchet et al., 2024).*

The conceptual framework illustrated in Table 3 identifies three key economic channels through which the effects can materialize: *1)* the Income Side, which captures labour market disruptions and wage dynamics; *2)* the Expenditure Side, which reflects rising costs of energy and essential goods, and can disproportionately affect low-income households due to their consumption pat- terns; and *3)* and the Government Side, which encompasses fiscal policies, such as carbon tax and revenue recycling, that can either mitigate or amplify inequality. The framework in Table 3 shows the complexity of the relationship between environmental policy stringency and income inequality, demonstrating that the nature of the impact of environmental policy stringency depends on three key factors: (1) the policy tool, (2) the sector addressed, and (3) the design of the policy. These factors, impacting whether the environmental policies mitigate or exacerbate income disparities, highlight the need for careful policy design to ensure equitable outcomes. These policy-specific factors, however, also interact with broader macroeconomic forces that shape the distribution of income. Hence, the control variables GDP per capita, unemployment, and social public expenditure were included in the analysis.

**Table 3. Transmission channels between environmental policies and inequality.**

| Channel category | Transmission channel | Sources | Expected effect of environmental policy stringency on inequality |
|---|---|---|---|
| Income Side | Labour market shifts from brown to green sectors | Baran et al. (2020), Chateau et al. (2018), Karagianni and Pempetzoglou (2022), Pavloudakis et al. (2023), Cha (2017) | Increasing |
| | Reskilling | Chun (2024), Bray et al. (2022) | Decreasing |
| | Capital and Land Ownership Effects | Zachmann et al. (2022) | Increasing |
| Expenditure Side | Energy price increases | Voicu-Dorobant,u et al. (2021), Middlemiss (2022), | Increasing |

| Channel category | Transmission channel | Sources | Expected effect of environmental policy stringency on inequality |
|---|---|---|---|
| | | Bagus and Pena-Ramos (2023) | |
| | Transport cost increases | Sterner (2012), Flues and Thomas (2015), Berry (2019), Ohlendorf et al. (2021) | Mixed results |
| | Higher costs of food and essential goods | Angelico (2024) | Increasing |
| Government Side | Revenue recycling | Frondel et al. (2015), Carattini et al. (2017), Haug et al. (2018), R¨ub (2024) | Decreasing |
| | Public investment in green infrastructure and social programs | Liquete et al. (2015), Pauleit et al. (2019) | Decreasing |

*Note that these mechanisms are often context-dependent; therefore, the table presents general trends observed in the cited studies.*

## International analysis

The second component of this study extends the scope to cross-border effects, assessing whether stringent European policies may shift $CO_2$ emissions abroad via imports from the Global South. The data for $CO_2$ emissions were extracted from the EORA Global Supply Chain database, which offers global coverage for 190 countries and 26 harmonized sectors from 1990 onwards (Lenzen et al., 2013) (Although Eora's automated construction introduces uncertainties at fine sectoral and bilateral levels, it remains the only publicly available MRIO providing consistent sector-wise and country-wise trade and emissions data for both European and Global South economies. Aggregated analyses at the country-sector level are considered robust for cross-regional comparisons (Lenzen et al., 2013). The Input-Output (IO) data from EORA was used to calculate the factors of production, in this case $CO_2$ emissions, occurring in Global South countries, embodied in exports to 27 EU + EFTA countries.

Based on existing literature, there is some evidence of carbon leakage but that has focused on specific policy measures, such as the EU Emissions Trading System (Verde, 2020; Wang & Kuusi 2024) or Kyoto Protocol (Aichele & Felbermayr, 2015). This study, focusing on an extensive and internationally harmonised climate mitigation policy index, extends the carbon leakage analysis to 27 EU + EFTA (Complete list of importing countries: Austria, Belgium, Czechia, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Netherlands, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, United Kingdom, Bulgaria, Croatia, Estonia, Iceland, Latvia, Lithuania, Luxembourg, Malta, Romania, Switzerland) to capture the full geography of the EU's trade relations with the Global South (Complete list of exporting countries: Sub-Saharan Africa: Ghana, Senegal, Nigeria, Kenya, Tanzania, South Africa. Asia: India, Indonesia, Vietnam, Pakistan, Sri Lanka, Malaysia, Uzbekistan. Latin America: Argentina, Brazil, Chile, Colombia, Ecuador, Peru, Venezuela, Costa Rica. Middle East and North Africa: Egypt, Morocco, Jordan). Including smaller (with lower GDP or trade volumes) member states such as Bulgaria, Croatia, Estonia, Latvia, Lithuania, Malta, and Romania ensures a complete mapping of embodied emissions in imports.

The channel of carbon leakage under investigation here is that of international trade, which is associated with the pollution haven hypothesis (Copeland/Taylor, 1994). The hypothesis argues that the implementation of an environmental regulation will impact relative prices by increasing the costs of production within the regulated country - European countries in this study. The overall effect of the regulation will be a reduction in the demand for goods produced in the regulated country, while the demands for substitutes produced in the 'non-regulated' countries will increase. Lower demand hurts the profits of firms in the regulated country, which may incentivize them to move their production to a country with laxer environmental regulations (Copeland, 2004; Thomsen, 2021). Based on this framework, the second analysis investigates whether increased stringency of environmental policies in European countries shifts emissions abroad to Global South countries with weaker economies where environmental policies are laxer (De Beule 2022.; Koźluk and Timiliotis, 2016).

The literature identifies three channels by which carbon leakage can occur. The first channel, the competitiveness channel, refers to the changes in comparative advantages of the industries in the regulated countries that are emission-intensive and face competition via trade from non-regulated countries. Carbon mitigation policies raise production costs of the energy intensive markets which can lead to loss of competition and share in the international market. This prompts industries to shift production to non-regulating countries with lax environmental policies and cheaper production costs. The second channel refers to the changes in demand for energy intensive goods in regulated countries. Since climate policies affect the relative incomes and prices of goods, this shifts the demand from the regulated to non-regulated countries. The third, energy channel, is linked to fossil-fuel price changes and energy substitution effects. It is not directly relevant to our trade analysis therefore we focus on the first two channels.

The econometric analysis was conducted using a structural gravity model to estimate the effects of EPSI on carbon leakage in international trade. The gravity model of international trade, used for estimating bilateral trade flows and policy effects, is based on Newton's law of universal gravitational force, according to which the gravitational force between two objects is directly proportional to their masses and inversely to the squared distance between them. Translated to economics, this means that trade (or trade-related outcomes) depends positively on the economic size of trading partners and negatively on bilateral trade costs. The latter are captured by multilateral resistance terms (Anderson and van Wincoop, 2003). To calculate the emission embedded in imports, the following equation was parameterised:

$D_{imp} = S * L * Y_t$

Where $D_{imp}$ is emissions embedded in imports from global south countries to Europe, $S$ is direct emissions intensity of production in, multiplied with the Leontief matrix $L$ that includes the input-output ratios, to get *total* number $CO_2$ emissions along the entire production and supply chain that were emitted or used in service of creating that unit of output. This is then multiplied with $Y_t$, which is the final demand matrix of the importing country and includes only the imported portion of final demand.

Based on this theoretical foundation, the model includes importer-year, exporter-year, and pair fixed effects, in line with best-practice recommendations in gravity estimations (Piermartini & Yotov, 2016). The use of a multiplicative specification with Poisson Pseudo-Maximum Likelihood (PPML) allows for the inclusion of zero flows and addresses heteroskedasticity, ensuring unbiased and efficient estimates (Piermartini & Yotov, 2016). The final estimation equation is as follows:

$CO_{2ijst} = exp\{\beta_0 + \beta 1 EPSI_{jt} + \alpha_{ijs}\} + \varepsilon_{ijst}$

Where $CO_{2ijst}$ is emissions embodied in imports from Global South exporter $i$ to EU importer $j$ in sector $s$ and year $t$, $EPSI_{jt}$ is the stringency index of importer $j$ in year $t$, $\alpha_{ijs}$ is the fixed effect capturing all time-invariant heterogeneity between exporter $i$, importer $j$, and sector $s$, and $\varepsilon_{ijst}$ is the error term. The *exp* operator indicates the multiplicative PPML specification.

Together, these two analytical dimensions capture both the domestic distributional and the global spillover effects of environmental policy stringency. This twofold approach connects the internal equity dimension of the green transition with its external carbon footprint, thereby linking social and environmental justice perspectives within the same analytical framework.

# 4 Findings and results

## Domestic analysis

Before the estimation, several diagnostic tests were performed to confirm the data properties. The Pesaran and Yamagata (2008) slope-homogeneity test rejected the null of homogeneous slopes, indicating country-specific relationships between variables. The Fisher-ADF test confirmed cross-sectional dependence, implying that shocks in one economy affect others. Unit-root and cointegration tests (Westerlund 2008; Pedroni 1999) confirmed long-run relationships, justifying the use of the AMG estimator, which accounts for both cross-sectional dependence and slope heterogeneity.

Table 4 displays the results of the AMG estimation for each of the Gini coefficients. The results suggest that *EPSI* has a positive and statistically significant effect on *pre-tax* and *post-tax Gini*. *Pre-tax Gini* increases by 0.5% associated with an increase in environmental policy stringency by 10%, and *post-tax Gini* by 0.7%. *EPSI* does not have a statistically significant impact on *disposable Gini*. The robustness checks are consistent with the main estimation in terms of signs and order of magnitude, suggesting that the results are not driven by the estimation procedure. The per capita growth rate of GDP has a statistically insignificant relationship with *pretax* and *post-tax Gini* in the AMG estimation. However, *GDP p.c.,* shows a significant relation with *disposable Gini*, increasing it by 0.08% when increasing itself by 10%. Unemployment has a positive and statistically significant relationship with the *pre-tax* and *post-tax Gini* measures. *Pre-tax Gini* increases by 0.4% when unemployment increases by 10%, while *post-tax Gini* does so by 0.5%. Social public expenditure has statistically significant and negative relationships with all three estimations in Table 4. *Pre-tax Gini* decreases by 2%, *post-tax Gini* by 4.1% and *disposable Gini* by 2% when social expenditures increase by ten percent. The coefficient plot in Figure 1 visualizes the regression results, showing a consistent positive association between *EPSI* and inequality, while social expenditure (*SocX*) is strongly inequality-reducing.

The use of the three Gini measures is crucial to understanding not just the impact of environmental policies on income inequality in Europe, but also how the welfare state can mitigate or worsen these effects. Thus, the positive and significant relation between EPSI and pre-tax Gini reflects the market-driven inequality effects of environmental policy stringency, where structural change and labour-market reallocation amplify pre-distributional disparities. Stringent environmental measures reshape labour markets, disproportionately affecting low-skilled workers, especially those living in regions heavily dependent on fossil fuels (Baran et al., 2020; Chateau et al., 2018). As fossil-fuel sectors phase out, displaced workers often struggle to re-enter employment, especially where reskilling programmes remain inadequate (Haug et al., 2018; Chun, 2024; Seo, 2021). Wage stagnation and sectoral decline amplify the effect, as shown by Rud et al. (2024) in the UK coal-industry collapse, where earnings fell by up to 80–90 %. Rising energy and transport prices, driven by carbon pricing and subsidy removal, further burden lower-income households, reinforcing the regressive pattern (Frondel et al., 2015; Wier et al., 2005).

**Table 4. Regression results: effects of environmental policies' adoption and stringency on income inequality**

| **Dependent Variable** | **ln *Pre-tax Gini*** | **ln *Disp.Gini*** | **ln *Post-tax Gini*** |
|---|---|---|---|
| ln *epsi* | 0.054*** | -0.011 | 0.07*** |
| | (0.000) | (0.656) | (0.003) |
| ln *GDP p.c.* | -0.005 | 0.008*** | -0.0005 |
| | (0.206) | (0.000) | (0.916) |
| ln *Unemp* | 0.046** | 0.024 | 0.053** |
| | (0.016) | (0.535) | (0.026) |
| ln *SocX* | -0.187** | -0.176** | -0.415*** |
| | (0.003) | (0.045) | (0.000) |
| Comm. Dynamic Pr. | 0.354** | 0.486** | 0.187 |

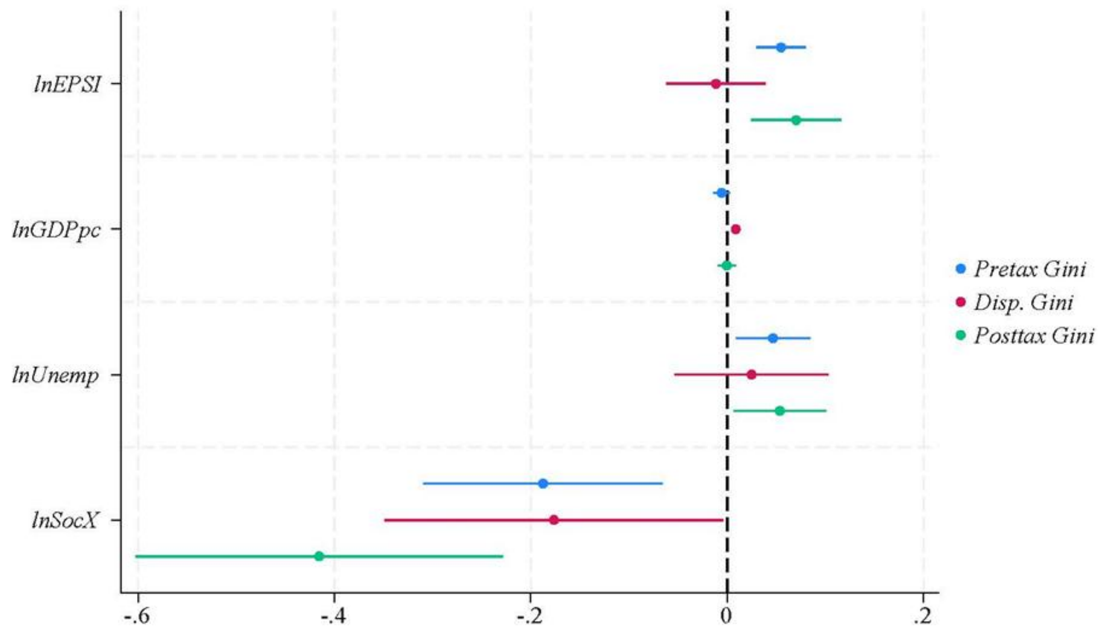
| | | | |
|---|---|---|---|
| | (0.023) | (0.020) | (0.180) |
| Constant | -0.381** | -0.512* | -0.120 |
| | (0.001) | (0.054) | (0.628) |
| Root Mean Squared Error (sigma) | 0.0295 | 0.0525 | 0.0420 |
| Observations | 510 | 469 | 510 |
| Number of country | 20 | 19 | 20 |

*AMG Estimation. ***p<0.01, **p<0.05, *p<0.1*

However, the results also point to an important compensatory mechanism: government intervention through social and tax policy mitigates disposable income inequality in the selected European countries in the first analysis. The insignificant relation between EPSI and the disposable Gini coefficient highlights that progressive taxation and direct cash transfers offset much of the inequality generated by environmental policies. Direct revenue recycling, through lump-sum “tax-and-dividend” payments, has proven effective in reducing the distributional consequences of environmental regulation (Burtraw et al., 2009; Frondel et al., 2015; Haug et al., 2018; Rüb 2024). Such measures compensate households, particularly those with low incomes, while preserving emission-reduction incentives. Complementary instruments like targeted hardship compensation further balance costs (Edenhofer et al., 2021).

However, the higher post-tax Gini coefficient reveals limits to redistribution via in-kind transfers such as education and healthcare (Giangregorio 2024; Palm et al., 2021). While in-kind transfers in terms of universal services such as healthcare and compulsory education do play a role in reducing inequality (Jianu, 2020; Pena-Sanchez et al., 2021), these effects may not be as strong in higher-income countries. Giangregorio (2024) finds that cash transfers generally reduce inequality more effectively than in-kind benefits, though the impact varies across welfare regimes: taxes and cash transfers have the strongest redistributive effects in Nordic countries, while in-kind benefits, particularly health and education, are most effective in Mediterranean systems. In high-income European welfare states, however, tertiary education and healthcare can become mildly regressive, as their benefits disproportionately accrue to higher-income households, highlighting the need for adaptive welfare design during green transitions. And although universal services reduce overall inequality, their redistributive power is weaker and slower to respond to rising living costs. Structural access barriers, such as rural gaps, disability, migration, restrict the reach of these services, limiting their effectiveness during rapid transitions (Palm et al., 2021).

**Figure 1. AMG Estimation Coefficient Plot**




Beyond policy stringency itself, labour-market dynamics and the level of social spending can impact the extent to which EPSI intensifies or mitigates income inequality. Rising unemployment increases both pre-tax and post-tax Gini values, indicating that job loss disproportionately harms low-income groups, the “outsiders” in segmented labour markets (Seo, 2021), a phenomenon captured succinctly by Doctorow (2022): “the last hired (women, racialized people) are the first fired, and the last to be re-hired.” This interaction between labour-market shocks and environmental policy stringency underscores the importance of integrating just transition policies within climate governance frameworks. The stronger effect on post-tax Gini underscores that in-kind support cannot fully replace lost earnings, whereas unemployment benefits cushion disposable income. Lastly, social expenditure consistently reduces inequality: a 10 % increase in *SocX* lowers pre-tax Gini by 2 % and post-tax Gini by 4 %, confirming its central role in mitigating both present and future inequality.

Overall, these findings show that environmental policy stringency increases inequality before redistribution, but strong welfare institutions, through targeted cash transfers and social spending, can effectively neutralise much of this impact.

## International analysis

Complementing the domestic analysis, the second analysis extends this perspective outward, exploring whether stricter EU policies contribute to emissions offshoring through trade with the Global South. The regression results are displayed in Table 5. The results of this analysis show that higher environmental policy stringency in Europe is strongly associated with higher levels of imported emissions from global south countries: If environmental policies become 10 percent more stringent, then emissions embodied in imports increase by 1.3 percent (The estimated effects were calculated in terms of the effect of a 10 percent increase in environmental policy stringency, with the resulting change in imported $CO_2$ emissions expressed as a proportion of their average level). The results were disaggregated to the level of different exporters in the Global South country (see Figure 2 and Figure 3, the latter is without Venezuela to make the coefficient plot easier to understand) and suggest that emissions are imported increasingly from most Southern countries in our sample (For a small number of countries (Bangladesh, Chile, Jordan, Kenya, Malaysia, Tanzania, Venezuela, and South Africa), the emissions decrease with increase in EPSI). When the results are decomposed by sector (see Figure 4), we can see that European countries are importing emissions from most of the 26 sectors in the Global south. The finding thus suggests that European decarbonisation has been partially externalised, with mitigation achieved domestically (Eslahi, Creti, & Sanin, 2026; Ugrinov, 2025; Green, 2021; Ziemblińska et al., 2025) but offset by increased embodied emissions abroad. The aggregate coefficient should be interpreted as the net effect of EPSI on imported, embodied emissions. Since CAPMF includes both carbon and non-carbon policies, the estimated elasticity of 1.3% is not solely from carbon-pricing measures but reflects the cumulative regulatory pressure across multiple environmental policy domains, including regulations on air pollutants (NOx, SOx, PM), industrial energy and resource-efficiency standards, and planning instruments related to renewables and resource use. This explains why the aggregate relationship, while statistically significantly positive, is moderate. Increasingly stringent environmental policies can trigger substitutions and adjustments across several sectors but may not force a full-scale relocation in all sectors. The positive coefficient of the aggregate EPSI is therefore a sign of broad environmental policy leakage effect, and, along with the sectoral decomposition, may be understood through a multichannel framework. The following discussion offers a general interpretation of sectoral differences rather than a detailed decomposition. Given that each industry has its own regulatory composition and exposure to specific policy instruments, a deeper sector-by-sector analysis would go beyond the scope of this study.

**Table 5. Regression results: effects of EPSI on emissions embedded in imports**

| **Dependent Variable** | **Emissions** |
|---|---|
| ln *epsi* | 0.0894***<br>(0.000) |
| Constant | 4.4766***<br>(0.000) |
| Observations | 156,000 |

Differences in the estimated sectoral parameters largely reflect two underlying structural factors: variation in emission intensity and relocation or tradability constraints. These factors can shape how the leakage channels on competitiveness, domestic demand, and compliance costs can operate across sectors. The competitiveness channel links higher environmental policy stringency to production costs. More emission-intensive and energy-dependent sectors face stronger cost pressures under market-based instruments such as carbon taxes or the EU ETS (Copeland & Taylor, 2004; IEA, 2008). However, only those activities that are both carbon-intensive *and* easily tradable can effectively relocate production abroad, which limits the channel's scope.

**Figure 2. Country-level coefficients for the CAPMF × Global South interaction in the PPML estimation**

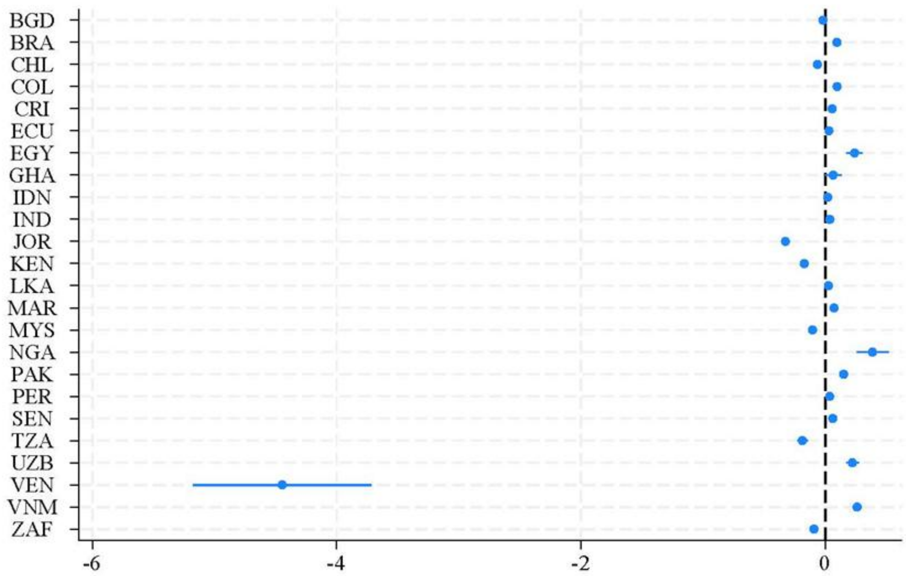
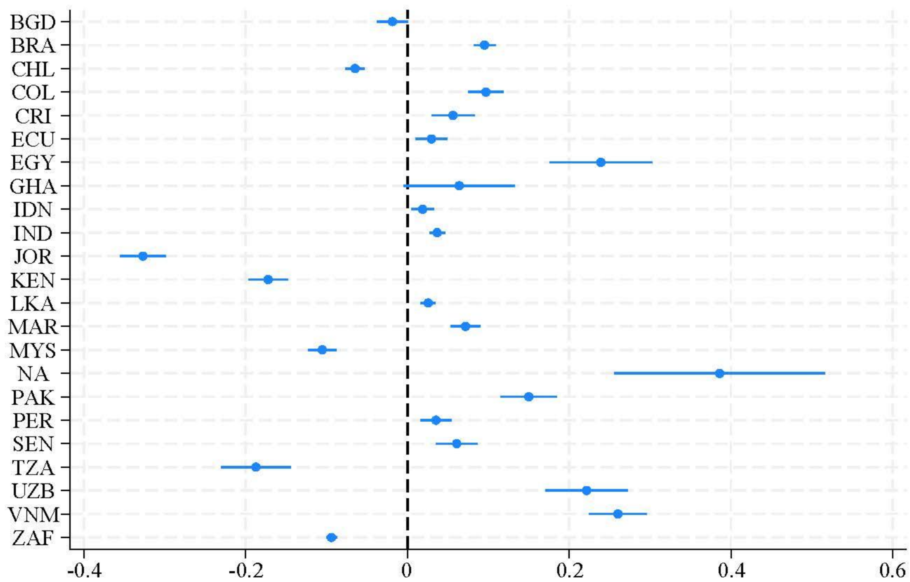
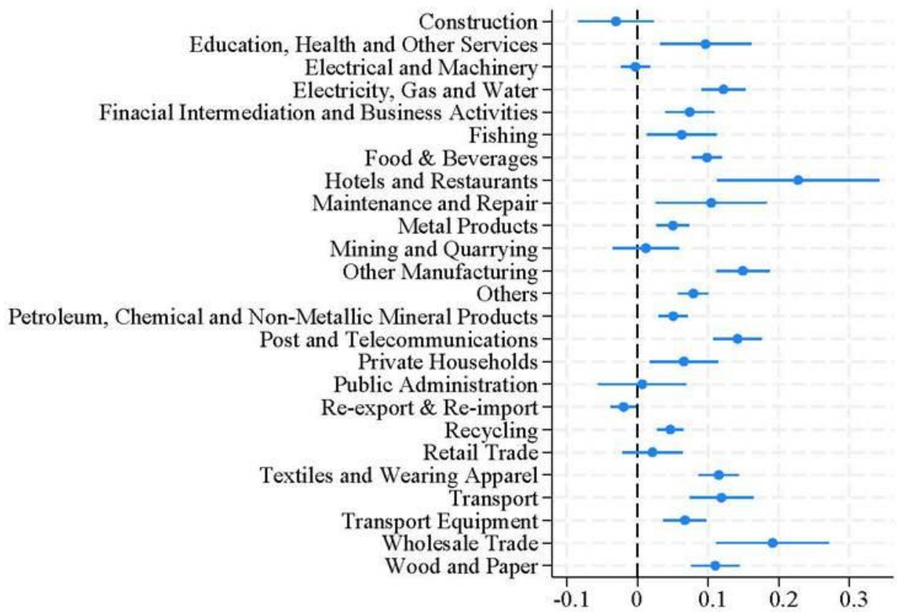



**Figure 3. Country-level coefficients for the CAPMF × Global South interaction in the PPML estimation (without Venezuela)**




The demand-substitution channel operates where relocation is difficult but trade in final or intermediate goods is feasible. In such sectors, higher compliance costs or product prices lead European firms and consumers to source more goods from countries with laxer standards, even when domestic production remains in place (Tan & Bin, 2018; Demiral et al., 2022). This mechanism helps explain why some low intensity yet highly tradable sectors show positive leakage coefficients. Finally, the compliance channel affects sectors exposed to non-price regulations such as technical standards, certification, or product bans, and these compliance costs that may differ across sectors. This would create a compliance asymmetry and can result in European suppliers externalising those compliance burden onto their partners in less regulated countries. While our analysis does not suggest that compliance costs are the main driving force of relocation, this mechanism works with the first two channels, incentivizing firms to move to regions where environmental regulation is less strict. Abbasi et al., (2023) uses a similar argument when examining whether Europe's industrial emission reductions are partly due to the outsourcing of pollution-intensive production abroad. They find that despite rising economic output in the EU, industrial emissions in the EU-28 declined markedly from 1995–2011, due to increase in emissions embedded in imports. They suggest that even if environmental regulation within the EU itself is not the main driver, the strictness of its enforcement in host countries can strongly influence where industries choose to relocate. Saussay and Soilita (2023) find that policy type also determines outsourcing decisions by firms, with environmental taxes having twice the effect of standards in driving cross-border investment and firms react more strongly to market-based instruments (taxes, permit prices) than to command-and-control standards.

**Figure 4. Sectoral coefficients for the impact of EU CAPMF on imported emissions**




In summary, the domestic and international analyses together reveal the dual nature of Europe's green transition. While stricter environmental policy stringency can increase inequality within countries, an effect largely mitigated through social spending and redistribution, it simultaneously externalises part of Europe's carbon footprint to less regulated economies through trade. This interplay between domestic adjustment and international displacement underscores that social compensation mechanisms exist nationally, but not globally, highlighting the need for policy coordination that balances climate ambition with both social and global justice.

## 5 Main results

In terms of distributional outcomes, the analysis finds that stricter environmental policies are associated with higher inequality in Europe. Specifically, a 10% increase in environmental policy stringency raises the pre-tax Gini by about 0.3% and the post-tax Gini by 0.5%, while having no statistically significant effect on the disposable Gini. These findings indicate that direct cash transfers, which are captured in the disposable Gini measure, help offset the regressive impact of climate policies. Unemployment is found to exacerbate both pre-tax and post-tax inequality, reflecting the vulnerability of low-income groups to structural job losses during the transition. By contrast, higher levels of social public expenditure consistently reduce inequality across all three Gini measures, underscoring the role of welfare systems in cushioning the social costs of decarbonisation. Overall, these results point to the social and socio-economic costs of the green transition, rising inequality and uneven burden-sharing, but also to important social benefits, as welfare and fiscal mechanisms significantly mitigate these effects.

In terms of environmental outcomes, the results show that higher environmental policy stringency in Europe is strongly associated with higher levels of imported emissions from Global South countries. A 10% increase in policy stringency leads to a 1.3% rise in emissions embodied in imports, suggesting that part of Europe's decarbonisation effort is achieved through the offshoring of carbon-intensive production. Disaggregated results confirm that imported emissions increase across most sectors and exporter countries in the Global South, indicating a broad pattern of carbon leakage rather than a sector-specific effect. These findings highlight both the environmental benefits of the green transition, reductions in territorial emissions and strengthened climate protection within Europe, and its environmental costs, namely the externalisation of emissions that undermines the global effectiveness of domestic decarbonisation.

The results from both analyses were confirmed by robustness checks, reinforcing the validity of these findings across alternative model specifications. Together, they underscore that while Europe's green transition delivers measurable environmental gains, its social and environmental costs are unevenly distributed, both within countries and across global production networks.

## 6 Discussion and conclusions

Reflecting on the empirical results of this study through the lens of the GreenPaths analytical framework, we can link the domestic and international findings to broader questions of environmental sustainability and social wellbeing. This case study analyses the consequences of environmental policies on distributive outcomes within Europe and environmental spillovers across its trade partners in the Global South. In doing so it contributes to GreenPaths' central objective of understanding how green transition policies in Europe can be socially fair, economically viable, and environmentally effective. By combining inequality and trade-emission analyses, our case study brings together two core dimensions of GreenPaths, social and environmental justice. Thus, revealing how policies that can reduce territorial emissions may also redistribute costs and benefits unevenly across people and places.

The GreenPaths analytical framework allowed us to shed light on two interrelated justice dimensions through this case study: distribution and recognition. Viewed through this lens, we find that the domestic analysis exposes the distributional dimension: stringent environmental policy tends to raise inequality before redistribution, but strong welfare institutions can mitigate these effects through targeted cash transfers and social spending. The international analysis, in turn, highlights that the benefits of European decarbonisation are partly achieved at the expense of partners in the Global South, where weaker environmental regulation and limited governance in global governance result in an unequal sharing of transition burdens. Together, the two analyses highlight potential injustices contained in Europe's green transition, where social costs are redistributed within nations, but negative environmental externalities affect partners globally.

In terms of distributional justice, the domestic analysis shows that stringent environmental policies, while essential for decarbonisation, can produce short-term regressive effects through labour-market and price mechanisms. As EPSI rises, the costs of energy and transport go up, and employment in carbon-intensive sectors declines, disproportionately affecting low-income and low-skilled workers (Baran et al., 2020; Chateau et al., 2018). But this outcome is not simply a loss of employment and income, but it represents a structural inability of the system to reintegrate those put out of work due to the transition as brown sector workers struggle to transition to other jobs. These struggles are further accompanied by wage stagnation and long-term decline (Kyriacou et al., 2024). This is particularly evident in cases where reskilling programs are inadequate or fail to match market demand, exacerbating labour market segmentation and inequality (Chun, 2024; Seo, 2021). Yet the analysis also reveals an important counterbalance from the state; higher social spending and progressive fiscal policies can offset much of the inequality generated by increasingly stringent environmental policies. This echoes GreenPaths' emphasis on the social impact processes of transition, specifically the relationship between employment, income, and welfare resilience, demonstrating that fiscal and social integration can ensure decarbonisation with social wellbeing.

The international component of this study extends the notion of distributional justice beyond European borders, uncovering the spatial redistribution of environmental costs. Rising EPSI levels associated with higher embodied $CO_2$ imports from Global South partners indicate that part of Europe's mitigation success is achieved through carbon leakage rather than absolute emission reduction. This points to the absence of a global policy on shared regulatory standards and redistributive mechanisms at the international level to prevent inequalities between high- and low-income regions. While welfare states can internalize and buffer domestic social costs, there are no similar instruments at the international level to prevent the externalization of environmental burdens in the green transition. That is one concern that the Carbon Border Adjustment Mechanism (CBAM) may be able to address (Bellora, 2023), although some ex-ante research finds that the effectiveness of the CBAM to address carbon leakage risks can be expected to be rather limited (Sun et al., 2024). This asymmetry is further reinforced when we consider that the Just Transition Funds and other regional support mechanisms at least partially recognize and support disadvantaged workers and regions within Europe. Verdolini et al. (2024) provide a detailed report on what the EU has done to support disadvantaged workers and regions affected by the green transition, especially those dependent on coal, fossil fuels, or carbon-intensive industries, through for example, the European Social Fund, or aiding coal-dependent areas like Silesia via the Coal Regions in Transition Platform. Under the European Green Deal, the Just Transition Fund and Mechanism now channel billions toward reskilling, job creation, and green regional development (Verdolini et al., 2024). In contrast, the ecological costs borne by producers and exporters in the Global South have been only partially addressed in European policy design, often considered indirectly through mechanisms such as the Carbon Border Adjustment Mechanism (CBAM) rather than through broader social or developmental frameworks.

The distributional consequences of this leakage are particularly concerning for exporting countries because many of these countries already face structural barriers to implementing stringent environmental policies in terms of limited fiscal resources, weak regulatory institutions, and competing development priorities (Sadik Zada and Ferrari, 2020). Consequently, production displaced from Europe and relocated to regions with lower enforcement capacity amplifies global inequities in environmental governance.

The two analyses together show how economic, social and environmental indicators interact and how current policy evaluation falls short in terms of fully integrating the three dimensions. The approach adopted in this study of bridging inequality, welfare, and trade demonstrates that integrating multidimensional indicators can reveal asymmetries and trade-offs that one-dimensional analyses can overlook. This case study thus contributes to GreenPaths' comparative understanding of how policy coherence and institutional design determine whether green transitions reinforce or alleviate inequality, both within Europe and globally.

Taken together, the domestic and international analyses reveal a two-sided outcome of European environmental policy stringency. Domestically, higher EPSI initially increases inequality through labour-market and price effects but is largely offset by redistributive welfare mechanisms. Internationally, however, the same policies externalise part of Europe's carbon footprint to less regulated economies, generating trade-based carbon leakage. This pattern illustrates the asymmetric effect of stringent environmental policy where social costs are redistributed within Europe via welfare systems and public social spending, while environmental costs are redistributed globally via trade channels. Both outcomes arise from the asymmetric capacities of domestic welfare systems and global regulatory frameworks: whereas European welfare states can cushion income shocks through transfers and social spending, global governance lacks equivalent mechanisms to address environmental spillovers. Hence, the combined results point to a critical tension in green transition policies, effective domestic mitigation coexists with global inequities unless complemented by coordinated carbon pricing, technology transfer, and just transition mechanisms that internalize cross-border impacts.

# 7 Recommendations

**Integrate welfare design into climate strategy at EU level:** Environmental policy stringency should be developed alongside targeted welfare measures at the European level to protect low-income and vulnerable groups during the transition.

**Prioritise direct cash transfers and progressive taxation:** Evidence shows that disposable income inequality remains stable when redistributive instruments are in place. Expanding cash-transfer schemes and revenue recycling from carbon pricing at the European level can help maintain fairness while preserving abatement incentives.

**Invest in reskilling and labour-market transitions:** Labour-market vulnerability is a key social cost of decarbonisation. Active labour policies regarding training, relocation support, and job guarantees, should accompany sectoral phase-outs to prevent long-term inequality.

**Monitor distributional impacts systematically:** Include social indicators (e.g. inequality, energy poverty, employment) in environmental policy evaluation frameworks to ensure that social costs are identified early and mitigated proactively.

**Link fiscal and environmental policy frameworks:** The analysis shows that high social expenditure mitigates the inequality effects of environmental stringency. Fiscal and climate policy planning should therefore be coordinated to prevent adverse, social outcomes.

**Recognise and manage carbon leakage as a social issue:** Beyond its environmental implications, carbon leakage redistributes production and employment risks to less regulated economies. EU policies should incorporate social safeguards for affected trade partners.

**Broaden the scope of the Carbon Border Adjustment Mechanism (CBAM):** While CBAM addresses price distortions, it should evolve to include developmental cooperation, capacity-building, and technology transfer measures that support exporters in meeting higher environmental standards.

# 8 References


Abbasi, G., & Bouman, E. A. (2020). Emissions outsourcing in the EU. *A Review of Potential Effects on Industrial Pollution. doi*, *10*.

Aichele, R., & Felbermayr, G. (2015). Kyoto and carbon leakage: An empirical analysis of the carbon content of bilateral trade. *Review of Economics and Statistics*, *97*(1), 104-115.

Anderson, J. E., & Van Wincoop, E. (2003). Gravity with gravitas: A solution to the border puzzle. *American economic review*, *93*(1), 170-192.

Angelico, C. (2024). The green transition and firms' expectations on future prices: Survey evidence. *Journal of Economic Behavior & Organization*, *221*, 519–543.

Bagus, P., & Peña-Ramos, J. A. (2023). Energy security and the transition toward green energy production. *Energies* 2023, *16*(6), 2920; https://doi.org/10.3390/en16062920

Baran, J., Szpor, A., & Witajewski-Baltvilks, J. (2020). Low-carbon transition in a coal-producing country: A labour market perspective. Energy Policy, 147, 111878.

Bellora, C., & Fontagné, L. (2023). EU in search of a Carbon Border Adjustment Mechanism. *Energy Economics*, *123*, 106673.

Berry, A. (2019). The distributional effects of a carbon tax and its impact on fuel poverty: A microsimulation study in the french context. *Energy Policy*, *124*, 81–94.

Blanchet, T., Chancel, L., Flores, I., Morgan, M., Alvaredo, F., Atkinson, A., Bauluz, L., Fisher- Post, M., Garbinti, B., Goupille-Lebret, J., Mart´ınez-Toledano, C., Neef, T., Piketty, T., Robilliard, A.-S., Saez, E., Yang, L., & Zucman, G. (2024). *Distributional national accounts guidelines methods and concepts used in the world inequality database.*

Branger, F., & Quirion, P. (2014). Would border carbon adjustments prevent carbon leakage and heavy industry competitiveness losses? Insights from a meta-analysis of recent economic studies. *Ecological Economics*, *99*, 29-39.

Bray, R., Montero, A. M., & Ford, R. (2022). Skills deployment for a 'just'net zero energy transition. *Environmental Innovation and Societal Transitions*, *42*, 395–410.

Burtraw, D., Sweeney, R., & Walls, M. (2009). The incidence of us climate policy: Alternative uses of revenues from a cap-and-trade auction. *National Tax Journal*, *62* (3), 497–518.

Carattini, S., Baranzini, A., Thalmann, P., Varone, F., & Vöhringer, F. (2017). Green taxes in a post-paris world: Are millions of nays inevitable? *Environmental and resource economics*, *68*, 97–128.

Cha, J. M. (2017). A just transition: Why transitioning workers into a new clean energy economy should be at the center of climate change policies. *Fordham Environmental Law Review*, *29* (2), 196–220.

Chateau, J., R. Bibas and E. Lanzi (2018), "Impacts of Green Growth Policies on Labour Markets and Wage Income Distribution: A General Equilibrium Application to Climate and Energy Policies", *OECD Environment Working Papers*, No. 137, OECD Publishing, Paris, https://doi.org/10.1787/ea3696f4-en

Copeland, B. R., & Taylor, M. S. (1994). North-South Trade and the Environment. *The Quarterly Journal of Economics*, *109*(3), 755–787. https://doi.org/10.2307/2118421

Copeland, B. R., & Taylor, M. S. (2004). Trade, growth, and the environment. *Journal of Economic literature*, *42*(1), 7-71.

Chun, H. K. (2024). Falling through the cracks? skilling, reskilling and upskilling for job transi- tions. In *Rethinking economic transformation for sustainable and inclusive development* (pp. 205–234). Edward Elgar Publishing.

De Beule, F., Schoubben, F., & Struyfs, K. (2022). The pollution haven effect and investment leakage: The case of the EU-ETS. Economics Letters, 215, 110536.

Dechezleprêtre, A., Gennaioli, C., Martin, R., Muûls, M., & Stoerk, T. (2022). Searching for carbon leaks in multinational companies. *Journal of Environmental Economics and Management*, *112*, 102601.

Demiral, Ö., Demiral, M., & Aktekin-Gök, E. D. (2022). Extra-regional trade and consumption-based carbon dioxide emissions in the European countries: Is there a carbon leakage? *Sustainable Development*, *30*(6), 1987-2001.

Doctorow, C. (2022). *This "inflation" is different. new stiglitz just dropped.* [Accessed: 2025-05- 27]. https://doctorow.medium.com/this-inflation-is-different-248b8538371b

Edenhofer, O., Kalkuhl, M., & Roolfs, C. (2021). Carbon pricing and revenue recycling: An overview of vertical and horizontal equity effects for germany. *CESifo Forum*, *22* (05), 10–14.

Eslahi, E., Creti, A., & Sanin, M. E. (2026). Mission accomplished? A post-assessment of EU ETS impact on power sector emissions reduction. *Ecological Economics*, *239*, 108784.

European Commission. (2019). *The European Green Deal*. Retrieved from https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en

Eurostat. (2025, July 21). *International trade in goods, by type of good*. Statistics Explained. Retrieved from https://ec.europa.eu/eurostat/statistics-explained/index.php?title=International_trade_in_goods

Flues, F. and A. Thomas (2015), "The distributional effects of energy taxes", *OECD Taxation Working Papers*, No. 23, OECD Publishing, Paris, https://doi.org/10.1787/5js1qwkqqrbv-en.

Frondel, M., Sommer, S., & Vance, C. (2015). The burden of Germany's energy transition: An empirical analysis of distributional effects. *Economic Analysis and Policy*, *45*, 89–99.

Giangregorio, L. (2024). Welfare type and income inequality: An income source decomposition including in-kind benefits and cash-transfers entitlement. *International Tax and Public Finance*, *31*(2), 367–403.

Green, J. F. (2021). Does carbon pricing reduce emissions? A review of ex-post analyses. *Environmental Research Letters*, *16*(4), 043004.

Gubello, M., & Dunne, S. M. (2025). The political economy of in-kind versus cash redistribution in Europe. *International Tax and Public Finance*, 1-37.

Haug, C., Eden, A., & de Oca, M. M. (2018). Addressing the distributional impacts of carbon pricing policies. *Berlin: adelphi*.

Jianu, I. (2020). The impact of government health and education expenditure on income in- equality in european union. *arXiv preprint arXiv:2007.11409*.

Juergens, I., Barreiro-Hurlé, J., & Vasa, A. (2013). Identifying carbon leakage sectors in the EU ETS and implications of results. *Climate policy*, *13*(1), 89-109.

Karagianni, S., & Pempetzoglou, M. (2022). The income distribution impact of decarbonization in greece: An initial approach. *Circular Economy and Sustainability*, *2* (2), 557–567.

Korzeniowska, A. M. (2021). Heterogeneity of government social spending in European Union countries. *Future Business Journal*, *7*(1), 38.

Koźluk, T. and C. Timiliotis (2016), "Do environmental policies affect global value chains?: A new perspective on the pollution haven hypothesis", *OECD Economics Department Working Papers*, No. 1282, OECD Publishing, Paris, https://doi.org/10.1787/5jm2hh7nf3wd-en.

Kyriacou, C., Fokaides, P. A., & Barbano, G. (2024). Deliverable D2. 1: Local CET plans framework, including stakeholders mapping and Skills Gap Analysis.

Lenzen, M., Moran, D., Kanemoto, K., & Geschke, A. (2013). Building Eora: a global multi-region input–output database at high country and sector resolution. *Economic Systems Research*, *25*(1), 20-49.

Liquete, C., Kleeschulte, S., Dige, G., Maes, J., Grizzetti, B., Olah, B., & Zulian, G. (2015). Mapping green infrastructure based on ecosystem services and ecological networks: A pan-european case study. *Environmental Science & Policy*, *54*, 268–280.

Nachmany, M., & Setzer, J. (2018). Policy brief global trends in climate change legislation and litigation: 2018 snapshot. *Grantham Research Institute on Climate Change and the Environment*.

Nachtigall, D., Lutz, L., Cárdenas Rodríguez, M. *et al.* The Climate Actions and Policies Measurement Framework: A Database to Monitor and Assess Countries' Mitigation Action. *Environ Resource Econ* 87, 191–217 (2024). https://doi.org/10.1007/s10640-023-00821-2

McWilliams, B., Tagliapietra, S., & Zettelmeyer, J. (2025). Reconciling the European Union's clean industrialisation goals with those of the Global South. In J. Pisani-Ferry, B. Weder di Mauro, & J. Zettelmeyer (Eds.), *Global action without global governance: Building coalitions for climate transition and nature restoration* (Paris Report 3, Chapter 6). Bruegel and CEPR.

Middlemiss, L. (2022). Who is vulnerable to energy poverty in the global north, and what is their experience? *Wiley Interdisciplinary Reviews: Energy and Environment*, *11* (6), e455.

Ohlendorf, N., Jakob, M., Minx, J. C., Schr¨oder, C., & Steckel, J. C. (2021). Distributional impacts of carbon pricing: A meta-analysis. *Environmental and Resource Economics*, *78*, 1–42.

Palm, W., Webb, E., Hern´andez-Quevedo, C., Scarpetti, G., Lessof, S., Siciliani, L., & van Ginneken, E. (2021). Gaps in coverage and access in the european union. *Health Policy*, *125*(3), 341–350.

Pauleit, S., Ambrose-Oji, B., Andersson, E., Anton, B., Buijs, A., Haase, D., Elands, B., Hansen, R., Kowarik, I., Kronenberg, J., et al. (2019). Advancing urban green infrastructure in europe: Outcomes and reflections from the green surge project. *Urban forestry & urban greening*, *40*, 4–16.

Pavloudakis, F., Karlopoulos, E., & Roumpos, C. (2023). Just transition governance to avoid socio-economic impacts of lignite phase-out: The case of western macedonia, greece. *The Extractive Industries and Society*, *14*, 101248.

Pen˜a-S´anchez, A. R., Ruiz-Chico, J., & Jim´enez-Garc´ıa, M. (2021). Dynamics of public spending on health and socio-economic development in the european union: An analysis from the perspective of the sustainable development goals. *Healthcare*, *9*(3), 353.

Pesaran, M. H., & Yamagata, T. (2008). Testing slope homogeneity in large panels. *Journal of econometrics*, *142*(1), 50–93.

Pedroni, P. (1999). Critical values for cointegration tests in heterogeneous panels with multiple regressors. *Oxford Bulletin of Economics and statistics*, *61*(S1), 653-670.

Piermartini, Roberta and Yotov, Yoto, Estimating Trade Policy Effects with Structural Gravity (July 27, 2016). CESifo Working Paper Series No. 6009. http://dx.doi.org/10.2139/ssrn.2828613

IEA (2008), *Climate Policy and Carbon Leakage*, IEA, Paris https://www.iea.org/reports/climate-policy-and-carbon-leakage

Ru¨b, D. (2024). Inequality beyond income quantiles: Distributional effects of climate mitigation policies. *Ecological Economics*, *216*, 108019.

Rud, J.-P., Simmons, M., Toews, G., & Aragon, F. (2024). Job displacement costs of phasing out coal. *Journal of Public Economics*, *236*, 105167.

Sadik-Zada, E. R., & Ferrari, M. (2020). Environmental policy stringency, technical progress and pollution haven hypothesis. *Sustainability*, *12*(9), 3880.

Saussay, A., & Zugravu-Soilita, N. (2023). International production chains and the pollution offshoring hypothesis: An empirical investigation. *Resource and Energy Economics*, *73*, 101357.

Seo, H. (2021). 'dual'labour market? patterns of segmentation in european labour markets and the varieties of precariousness. *Transfer: European review of labour and research*, *27*(4), 485–503.

Sterner, T. (2012). Distributional effects of taxing transport fuel. *Energy Policy*, *41*, 75–83.

Sun, X., Mi, Z., Cheng, L., Coffman, D. M., & Liu, Y. (2024). The carbon border adjustment mechanism is inefficient in addressing carbon leakage and results in unfair welfare losses. *Fundamental Research*, *4*(3), 660-670.

Tan, X., Liu, Y., Cui, J., & Su, B. (2018). Assessment of carbon leakage by channels: An approach combining CGE model and decomposition analysis. *Energy Economics*, *74*, 535-545.

Thomsen, S. F. (2021). The impact of environmental regulations on competitiveness and carbon leakage. *European Journal of Economics and Economic Policies. Advance Access Articles.*

Ugrinov, S. (2025). The effects of environmental taxes on environmental pollution in the member states of the European Union. *Economic Systems*, 101308.

Verde, S. F. (2020). The impact of the EU emissions trading system on competitiveness and carbon leakage: the econometric evidence. *Journal of economic surveys*, *34*(2), 320-343.

Verdolini, E., Look, W., Belpietro, C., & Persico, G. (2024). The European Union policy toolbox to support just transition. *Report No.: 24*, *2*.

Voicu-Dorobant, u, R., Volintiru, C., Popescu, M.-F., Nerˇau, V., & S, tefan, G. (2021). Tackling complexity of the just transition in the EU: Evidence from Romania. *Energies*, *14* (5), 1509.

Wang, M., & Kuusi, T. (2024). Trade flows, carbon leakage, and the EU Emissions Trading System. *Energy Economics*, *134*, 107556.

Wang, Q., Hubacek, K., Feng, K., Wei, Y.-M., & Liang, Q.-M. (2016). Distributional effects of

carbon taxation. Applied energy, 184, 1123–1131.

Westerlund, J. (2008). Panel cointegration tests of the Fisher effect. *Journal of applied econometrics*, *23*(2), 193-233.

Wier, M., Birr-Pedersen, K., Jacobsen, H. K., & Klok, J. (2005). Are co2 taxes regressive? evidence from the danish experience. *Ecological economics*, *52* (2), 239–251.

Zachmann, G., Fredriksson, G., & Claeys, G. (2022). *Distributional effects of climate policies.*

Ziemblińska, K., Urbaniak, M., Jinlong, H., Olejnik, J., & Kundzewicz, Z. W. (2025). Decoupling of economic growth and CO2 emissions in 11 European Union Member States in Central and Eastern Europe. *Sustainable Energy Technologies and Assessments*, *82*, 104482.

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