The EU must stop carbon leakage at the border to become climate neutral

Justus Böning, Virginia di Nino, Till Folger / 8 Aug 2023

The Emissions Trading System has been the cornerstone of the EU's efforts to achieve climate neutrality by 2050. However, as currently implemented, it does not charge a price for the carbon embedded on import goods. This column shows that while the scheme has been successful in curbing the EU's carbon emissions, this has come at the cost of increased imports of carbon-intensive goods. It also highlights how the extent to which firms can outsource their carbon emission depends on ownership structure, with foreign-owned firms better placed to reorganise production to avoid the scheme.

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The EU is determined to achieve climate neutrality by 2050. The environmental benefits of this resolution will be global, but will the burden be equally shared worldwide? What is the risk for the EU to incentivise relocation or imports of high carbon footprint production from emissions havens?

Carbon leakage [1] is a risk of environmental policies adopted without international coordination (Ishikawa and Cheng 2021). While scholars tend to agree that leakage has remained limited after the introduction of the EU Emissions Trading System (ETS) (Dechezleprétre et al. 2022, which represents the cost companies must pay for polluting in the EU and thus determines the incentive to relocate to unregulated regions, has increased considerably.

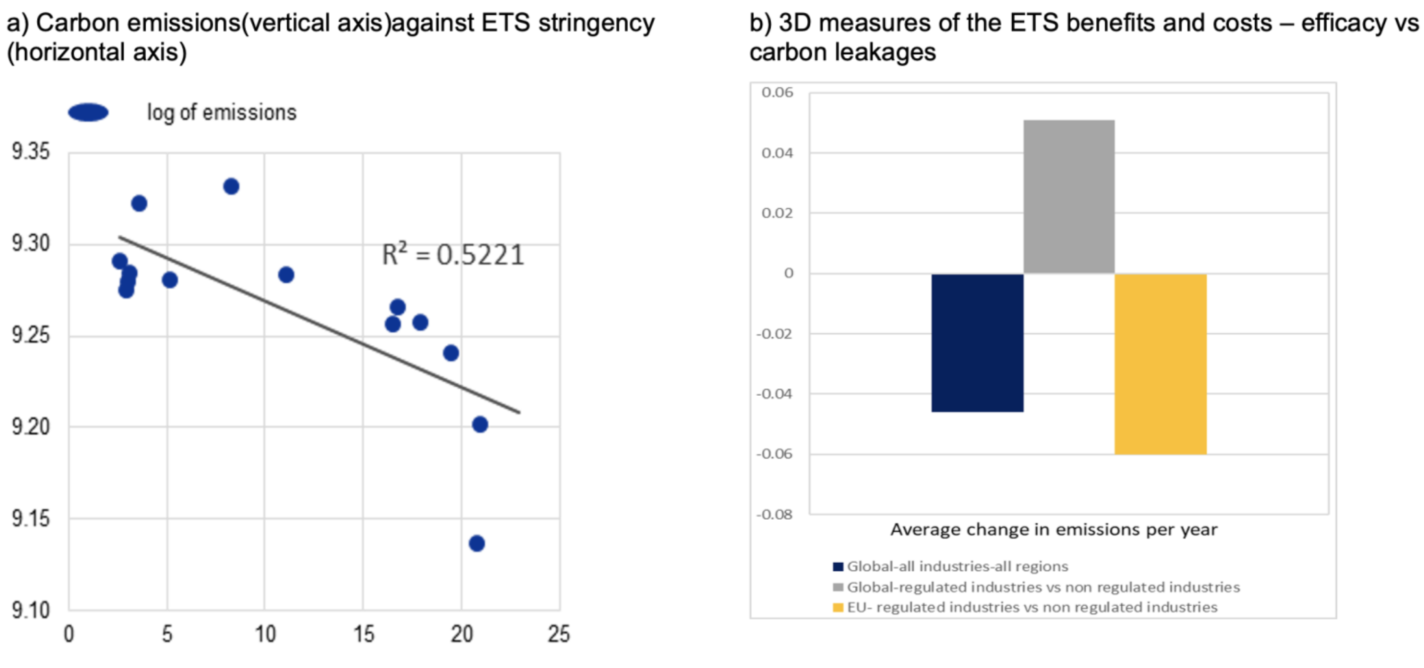
Against this backdrop, to preserve competitiveness of firms in the region and prevent carbon leakages, a carbon border adjustment mechanism (CBAM) on imports will charge foreign companies the same price paid by local businesses for their emissions when supplying the EU. By charging the same price irrespective of the geographical location of emissions and producers, the CBAM aims at placing companies on an equal footing in the EU market, offsetting eventual competitiveness losses.

In this column, we contribute to the debate about the efficacy of EU green policies and their fallout on EU firms' competitiveness in three distinct ways. First, we provide new evidence on the ETS efficacy in curbing EU carbon emissions; at the same time, we highlight that the success came with costs. Carbon leakage occurred in regulated industries, and they appear less negligible than previously identified. Second, we present the result of a novel study about the anti-competitive effects on EU industries associated to the ETS implementation. We shed light on the fact that uniformly applied policies can still produce differential effects on firms' output depending on their company's ownership structure. Finally, because the choice to introduce a CBAM is connected to incentives for companies to dodge costly regulation, our analysis sheds light on the conditions under which it could deliver the EU's climate neutrality goal (Böning et al. 2023).

The ETS has delivered on its mandate, but prompted carbon leakage in regulated industries

A provisional deal on a revised ETS has already been reached and the discussion about introducing a CBAM on imports are at an advanced stage.[2] A prerequisite for the new deal to work is proving that the existing ETS scheme has indeed reduced regional and global emissions. We determine the effectiveness of the ETS in two ways. Firstly, by looking at yearly emissions we can see that these are negatively correlated with ETS stringency, which is proxied by the share of traded in total allowances in the previous year.[3] The linear negative association explains more than half of the variance in the average log of yearly emissions (see Chart 1). These are estimated to have declined by about 2 percentage points more for each unitary increase in the ETS stringency.[4] The economic mechanism can be summarised by some firms investing in cleaner technology and selling unneeded emissions allowances. Meanwhile, other firms may cut back on production, thereby reducing emissions and allowing them to sell the saved emissions permits. To corroborate this hypothesis, we also find that pricier emissions and more stringent caps accelerated the EU greening process after 2013. Thereby, we conclude that the pricing mechanism was effective as emissions declined faster the higher the stringency and the higher the price of each emission permit, in line with other analyses in the literature (Känzig 2023).

Figure 1 ETS efficacy and associated carbon leakages



***Sources*: Tonnes of CO2 equivalent greenhouse gas emissions are from the European Environment Agency (EEA), which also provides the number of allowances and the amount of surrendered emissions by sector and country since 2005.**
***Notes*: The sectoral emissions plotted in the left hand side chart were regressed against sectoral trends, country, time and sector characteristics then averaged across sectors. The scatter bin-plot show that the emissions, unexplained by these determinants, correlate negatively with the ETS stringency. ETS stringency is proxied with the lagged value for the shares of traded allowances over total allowances. The 3D measure of ETS benefits and costs are derived from a diff-in-diff-in-diff estimate of yearly log emissions between 2005 and 2018, on its lagged value, country, sector, time fixed effects price of emissions, sectoral trend and country deterministic trends. The blue bars is the reduction in global emissions after the ETS came into force in 2005. The grey bar shows the change in emissions in ETS industries but global level. They are offsetting the global reduction. Last, the yellow bar depicts the average change in emissions of ETS industries in the EU relative to the average change in emissions of the same industries but**

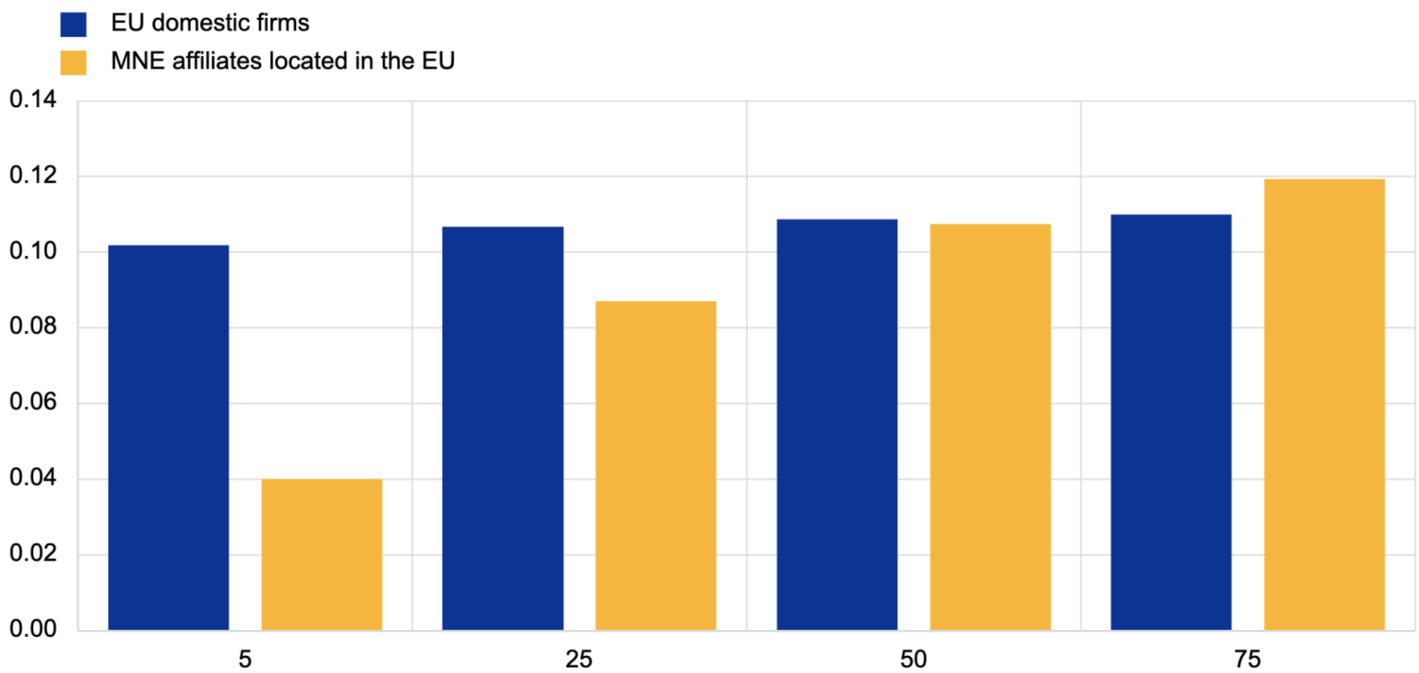
However, these achievements came with costs that are uncovered when the study is extended to unregulated industries and regions. A distinct analysis estimates the ETS's efficacy through a '3D' (difference-in-difference-in-difference) approach which leverages on the triple dimensional (time-sector-region heterogeneity) to identify the scheme's effects, while controlling for emissions autoregressive processes, sectoral trend and time, industry and country fixed effects. This second analysis confirms that the ETS resulted in cuts in the EU's GHG emissions of approximately 2–2.5 percentage points per year. Nevertheless, unlike earlier studies which found limited empirical evidence of carbon leakages, our analysis finds that heavy emissions activities increased outside the EU, as emissions in regulated industries within the EU declined. Against a backdrop of declining emissions since 2005 (Figure 1b, blue bar), the global yearly emissions by regulated industries rose over the same period (grey bar). Thus, the additional reduction in regulated industries within the EU (yellow bar) were offset by a simultaneous rise in emissions of those same industries elsewhere. This runs counter to the EU's efforts to also help reduce emissions globally.

The ETS's anti-competitive effects: A guide for the equal footing of the CBAM

In order to see whether the ETS equally incentivised all companies to relocate or import emission intensive inputs, we utilised information on sectoral output values and input-output linkages. We also distinguished companies by location (within and outside the EU) and ownership structure (domestic and foreign affiliates of multinational enterprises) which we match with industry's emissions and ETS prices. [5] We then regress the value of production by sector-country and ownership type on (1) emissions intensity by sector-country-ownership type, (2) exposure to emission intensive inputs distinguishing them by sourcing region (EU and outside the EU), and (3) the cost of the exposure to EU ETS regulation. [6] The aim is to verify whether a uniform regulation can trigger differentiated effects depending on the companies' ownership and the exposure of production to high-carbon footprint inputs, which are either sourced from within the EU and, hence, covered by the ETS or from outside the EU.

We find the EU production in regulated sectors to generally be more sensitive to emissions intensity than non-EU production, irrespective of the company ownership structure. We also find that purchasing high-emission inputs from within the EU translates into a competitive disadvantage for companies located within the EU. For these companies, shifting the sourcing of inputs from within to outside the EU raises total production but to a different extent for domestic and foreign owned companies. Specifically, the production of domestically owned companies in regulated industries from within the EU correlates negatively with the share of high-carbon footprint inputs sourced from within the EU and correlates positively with the share of the same inputs when they are sourced from outside the EU. Production of foreign-owned companies behaves similarly in terms of correlations across sourcing regions. However, the impact of a reshuffling across sources of emission intensive inputs from within to outside the EU grows larger as the price for allowances rises (Figure 2). Because ETS prices have risen in recent years and are anticipated to continue growing as the FIT-for-55 package comes into force, the incentive to change sources for foreign owned companies is ever growing. Against this background, foreign-owned companies seem better placed to dodge the regulation and reshuffle their inputs sources in favour of those located outside the EU unless these are also held accountable for their emissions when supplying the EU customers. The analysis does not reach the same conclusions when investigating production of companies located in the EU but operating in unregulated sectors; reshuffling across input sources in this case did not lead to any sizeable increase in total production, at least not for the time under consideration.

Figure 2 Sourcing high-carbon footprint inputs: The effect on production of a 1 percentage point shift from the regulated EU to unregulated regions (in percentage points)



Sources: **OECD-AMNE, authors estimations**
Notes**: The chart depicts the effect of a hypothetical shift by one percentage point across sourcing regions of high carbon footprint inputs from within**

depending on regions they are originated, e.g. from within and outside the EU. The specification also includes the interaction of these shares with the price paid on allowances in t-1, to capture the non-linearity of exposure to ETS regulation depending on the cost/price for allowances. The equation specification encompasses also deterministic country and industry trend and time unobserved heterogeneity, besides proper country-sector-ownership type fixed effects. Matching the AMNE and WIOD databases eventually yields 34 sectors and 44 countries (including RoW) spanning 2000-2016. Regulated (ETS) industries are Coke and refined petroleum products (C19), Basic metals (C24), Other non-metallic mineral products (C23), Electricity, gas, water, waste and remediation (DTE), and Transport and storage (H).

Conclusion

Overall, our study confirms that the ETS is effective in curbing EU emissions, but at the cost of burdening companies in the EU, especially domestic ones, and triggering carbon leakages. Different sensitivity of EU production to sourcing of emissions-intensive inputs depending on the company's ownership, suggests that some business models may have more leeway in reorganising production processes and sourcing high-carbon footprint inputs from outside the EU. Because the new EU environmental legislation aims at preventing similar behaviour through the CBAM, there is a need for a careful design of this mechanism, in terms of equivalent tariff charged on emissions embedded in imports and of CBAM industry's coverage. Our analysis advises in favour of extending the application of a CBAM on all regulated productions.

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Footnotes

1. According to the European Commission website, "[c]arbon leakage refers to the situation that may occur if, for reasons of costs related to climate policies, businesses were to transfer production to other countries with laxer emission constraints. This could lead to an increase in their total emissions. The risk of carbon leakage may be higher in certain energy-intensive industries" (https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets/free-allocation/carbon-leakage_en)

2. Both these tools are devised to strike the best possible trade-off between carbon emissions reduction and the preservation of production competitiveness in the region by minimising the occurrence of carbon leakages also taking into consideration administrative, technical and political aspects related to their enforcement. The remodelled ETS envisages stricter trading rules, extends the industry coverage, in particular to transport and buildings, and cuts more decidedly on emission allowances. More importantly it gradually phases out the free carbon allowances, granted to emission-intensive and trade-exposed (EITE) industries to prevent carbon leakages. The EITE industries are those with an increase in direct and indirect production costs induced by the ETS, as a proportion of the gross value added, by at least 5%; and that operate in sectors with trade intensity with non-EU countries (imports and exports) above 10%. In this context, a CBAM on imports of certain EITE products (cement, iron, steel, aluminium, fertilisers, and electricity) is phased in as of 2026 to guard EU production from the competition of foreign companies operating in unregulated regions. Importers will buy certificates proportional to the emissions embedded in imports at the ETS market price. For further details, see https://www.consilium.europa.eu/en/press/press-releases/2022/03/15/carbon-border-adjustment-mechanism-cbam-council-agrees-its-negotiating-mandate/ https://www.consilium.europa.eu/en/press/press-releases/2022/12/18/fit-for-55-council-and-parliament-reach-provisional-deal-on-eu-emissions-trading-system-and-the-social-climate-fund/. Stepping up Europe's 2030 climate ambition - Investing in a climate-neutral future for the benefit of our people," Communication.

stringency is defined by the share of traded allowances over total surrendered allowances per regulated sector at t-1. Intuitively if in a given period companies were forced to purchase a higher share of total emissions, their production cost will increase proportionally to the spending on allowances, incentivizing them to cut down on emissions the year after. This is what our empirical estimates confirm.

4. The sectoral emissions are regressed against sectoral trends, country, time, sector characteristics, the ETS stringency (e.g. share of traded in total allowances) and the cost associated to the traded emissions.

5. Data on gross output by country and sector, the share of emission-intensive inputs and imports on total were obtained from the OECD AMNE database that distinguishes companies according to domestic and foreign ownership (see Cadestin et al. 2018). The period covered spans 2005-2016

6. The exposure is defined by the share of high carbon footprint inputs on total inputs. The cost is the same share multiplied by the price of emission allowances per period. In the attempt to eliminate any bias which could affect the results coming from other unobservable factors affecting production which are unrelated to the ETS, the analysis controls for 3D fixed effects (sector-country-ownership), include time fixed effects and sectoral and country deterministic trends.

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THEMES

CLIMATE CHANGE EU POLICIES

KEYWORDS

CARBON LEAKAGE EMISSIONS TRADING SYSTEM

SHARE

VoxEU COLUMN

Pricing of carbon within and at the border of Europe

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6 MAY 2021 ENVIRONMENT / EU POLICIES

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Carbon tax, cross-border carbon leakage, and border tax adjustments

Jota Ishikawa, Haitao Cheng

16 SEP 2021 ENVIRONMENT

VOXEU COLUMN CLIMATE CHANGE

Sovereign emissions: Circumstances versus effort

Zornitsa Todorova, Carlos Garcia, Maggie O'Neil, Charlotte Edwards, Jordan Isvy, Christian Keller / 14 Oct 2024

Evaluating sovereign emissions closely resembles the nature versus nurture debate; we must consider both the inherent structural factors of countries such as demography, geography, and climate and the discretionary policies countries adopt to protect the environment and promote sustainability. This column introduces a new global sovereign emissions model, which shows that more than 50% of the differences in sovereign emissions can be explained by inherent structural factors outside of the control of countries.

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Sovereign emissions are seeing greater scrutiny from both investors and policymakers, but the challenge remains of how to systematically evaluate outcomes and allocate responsibility. There exists a continuum of intensity metrics and approaches to sovereign emissions accounting, including production-based (UNFCC 2008), consumption-based (Tukker et al. 2020, Cheng et al. 2022), extraction-based others specialise in services; some are ageing, others are in the midst of a population boom; some are located in extreme climates, while others are located in temperate climates.

Sovereign emissions likely reflect many of these structural differences, which in turn can affect how countries rank against each other. The question then is how can investors and policymakers better understand the drivers of sovereign emissions and improve their risk management and engagement strategies?

Carbon emissions: A product of circumstance or environmental policy?

In a recent paper (Todorova et al. 2024), we introduce a conceptual framework of sovereign emissions that allows us to compare structural circumstances versus policy effort. Structural factors are drivers of emissions that countries are born with – i.e. geographic or socioeconomic parameters – which for the better part are unrelated to environmental policy. Hence, depending on their structural factors, the baseline or expected level of emissions could differ greatly by country. For some countries, circumstances have worked against them – for example, all else equal, countries that regularly experience very hot summers or very cold winters will have a higher demand for heating or cooling services, and hence higher emissions. For others, circumstances have helped them reduce emissions – for example, countries that have historically specialised in services or countries that have deindustrialised over time tend to have lower emissions.

Factors related to environmental and sustainability policy, on the other hand, include discretionary measures countries have taken to reduce their emissions, irrespective of or even despite their circumstances. For example, countries cannot change the natural climate and geography they are endowed with, but the mix between fossil fuels and clean energy that is used for heating and cooling is an outcome that can be influenced by policy. Further examples include R&D in sustainability technology and carbon taxes.

We argue that for a fairer and more holistic comparison across countries, we should evaluate countries based on their active effort to protect the environment, adjusting for circumstances that are outside of their control.

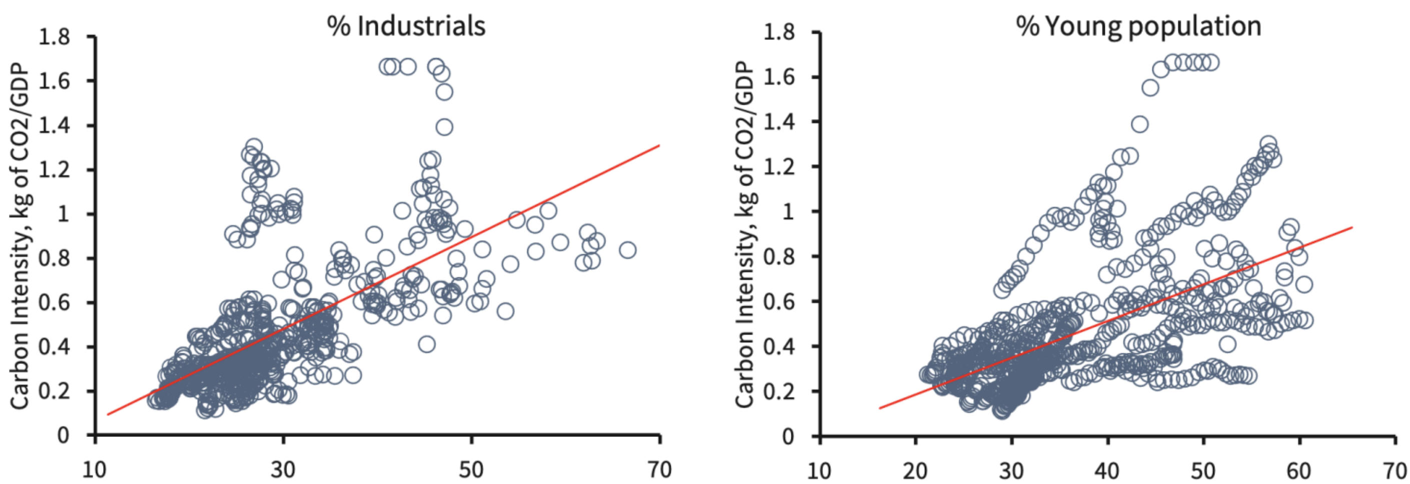
A systematic framework of sovereign emissions

We collected data on the carbon emissions for 21 countries over the period from 1990 to 2021. Our sample includes both developed and emerging market economies and covers over 70% of total global emissions. We normalise by GDP to account for differences in the size of the economy, and call this measure the carbon intensity of GDP.

We analyse the impact of a wide range of structural variables related to the composition of the economy, international trade flows, demographics, geography, and natural climate. As an example, Figure 1 shows the correlation between carbon intensity and the share of industrials as a percentage of GDP (left panel) and the percentage of young population (right panel). We find that a higher industrialisation and a younger population correlate with higher carbon intensity.

Other factors that correlate with higher carbon intensity are a denser population, a higher share of agricultural land, and a more extreme climate. Using a more formal panel regression approach, we find that taken together, structural factors explain more than 50% of the differences in global sovereign emissions.

Figure 1 Sovereign emissions and structural factors

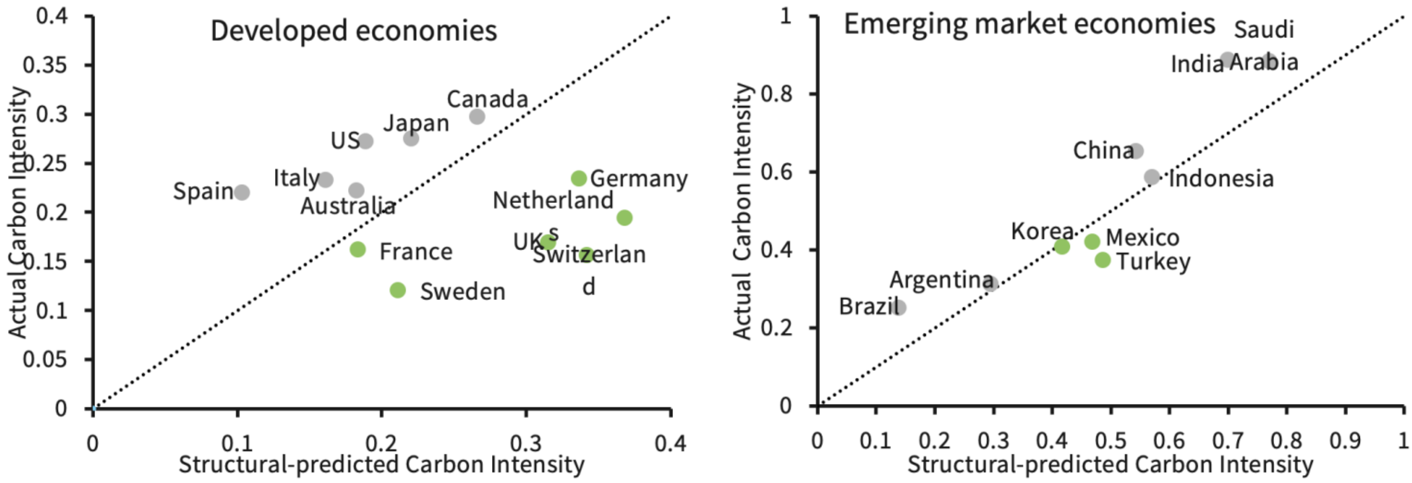


***Notes*: Percentage of industrials refers to the value added by the extractive industry, manufacturing, construction and utilities, expressed as a percentage of GDP. Percentage of the young population refers to the share of population under 25 years old.**
***Source*: World Bank**

A novel measure of green effort

In Figure 2, we plot the model-predicted carbon intensity, i.e. the carbon intensity implied by a country's structural factors (horizonal axis) against the actual carbon intensity (vertical axis), using data for 2021 as an example. By comparing the predicted and the actual values, we by policymakers to protect the environment. Countries below the 45-degree line of equal fit have lower-than-predicted carbon intensity (green countries) and countries above the line have higher-than-predicted carbon intensity (grey countries).

Figure 2 The green residual



***Source*: Barclays Research, World Bank, Global Carbon Project**

Using this new measure, we find that as of 2021, developed countries such as the US, Japan, and Canada appear as countries with low levels of green effort, whereas countries such as Germany, the UK, and Switzerland appear as countries with high levels of green effort. In the emerging markets group, Korea and Mexico are examples of countries that rank higher on green effort, whereas China, India and Brazil rank lower.

Policy implications

The fact that the structural component explains more than 50% of the cross-country differences in emissions illustrates why it could be hard to detect progress towards protecting the environment. There might be a significant delay between the implementation of green policies and the visibility of their results. In the meantime, the structural component might still completely overwhelm the green component, making it harder to detect progress.

Further, our framework could help policymakers and investors to better understand the drivers of sovereign emissions and attribute any changes to the correct sources – i.e. a change in circumstances or a change in policy effort. For example, since 1990, most developed countries in our sample have decreased their carbon intensity by between 20% and 30%. However, we attribute between 10% and 15% of this decrease to the coincidental declining contribution of industrial production to GDP and a transition towards a more services-based economy.

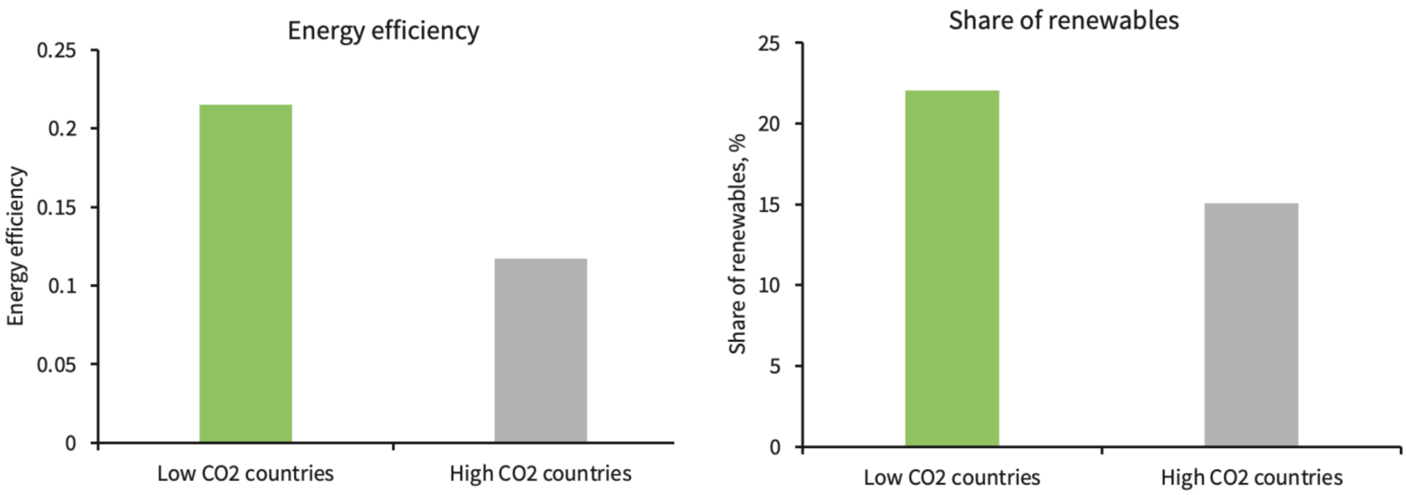
This suggests that circumstances have so far helped developed countries reduce their carbon footprint. However, as these economies face headwinds on the back of supply chain disruptions, slowing globalisation after the COVID-19 pandemic, and geopolitical uncertainty related to international trade flows, the share of industrial activity is expected to rise. This suggests that as circumstances move against them, developed countries might have to focus more on sustainability policy to meet their carbon emission reduction targets.

Discussion

The key insight of our study is that analysing sovereign emissions closely resembles the nature versus nurture debate – a more holistic evaluation requires that we consider the effect of both circumstances and policy decisions. Structural differences significantly complicate the debate and introduce important nuances. For example, Andreou et al. (2024) show that the effectiveness of market-based initiatives such as the EU Emissions Trading System critically depends on national structural characteristics such as the presence of skilled labour and technological infrastructure.

Our framework helps to illustrate the difficult challenge that policymakers will continue to face in the future: economic growth and sustainability are influenced by similar factors, but often in opposing ways. In our model, younger demographics correlate with worse emissions outcomes, but economic theory predicts that population growth increases the labour supply, which then translates into higher economic growth. However, recent research shows that for many developed countries, the historically positive relationship between carbon intensity and economic growth has weakened recently (Loungani 2018). According to our analysis this decoupling has occurred through two channels: investments in renewables and advances in energy efficiency (Figure 3).

Figure 3 Decoupling economic growth and emissions through investments in renewables and energy efficiency



***Notes*: Energy efficiency is measured as the amount of GDP produced by one unit of energy. All bars show 2017-2019 averages for high growth countries. High growth countries are defined as those countries whose cumulative growth over the last 10 years was above the sample median.**
***Source*: World Bank, IEA**

The challenge remains that financing clean energy projects often requires high upfront spending (Dees and Seghini 2024). This might be particularly challenging in macroeconomic environments of high interest rates or for developing countries, which typically face higher cost of capital and have weaker capital markets.

Achieving net zero will require policy interventions, drastic shifts in behaviour, and above all a great degree of international cooperation to ensure that the strategies are realistic and fair.

Authors' note: The views expressed in this column reflect the opinions of the authors and do not necessarily express the views of Barclays.

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VOXEU COLUMN CLIMATE CHANGE

Why unilateral decarbonisation can pay for itself

Diego Känzig, Adrien Bilal / 13 Feb 2025

Anthropogenic greenhouse gas emissions are rapidly warming our planet, with potentially severe economic, social, and health consequences. Conventional estimates of climate damages suggest that while coordinated global efforts are desirable, unilateral action is rarely cost-effective due to a classic free-rider problem. Why should a country bear the costs of reducing emissions when the benefits are shared globally? This column re-evaluates this view in light of new climate damage estimates based on global temperature variation, showing that the economic case for unilateral decarbonisation is far stronger than previously thought.

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Climate change poses a pressing challenge for policymakers worldwide. While most economists agree that coordinated global action is needed to address climate change, achieving such coordination has proven particularly difficult. Global emissions continue to rise despite developments in international negotiations since the 2015 Paris Agreement.

The perceived free-rider problem is a key barrier to coordinated climate action: countries that reduce emissions bear the full costs, while the benefits are shared globally. This 'tragedy of the commons' creates a strong disincentive for unilateral action. Under conventional estimates of climate damages, coordinated global efforts are desirable while unilateral action is rarely cost-effective (e.g. Barrage and Nordhaus 2024).

New research challenges this presumption. In Bilal and Känzig (2025), we find that when accounting for the broader economic impacts of global temperature changes, unilateral decarbonisation can actually pay for itself for large economies like the US or the EU.

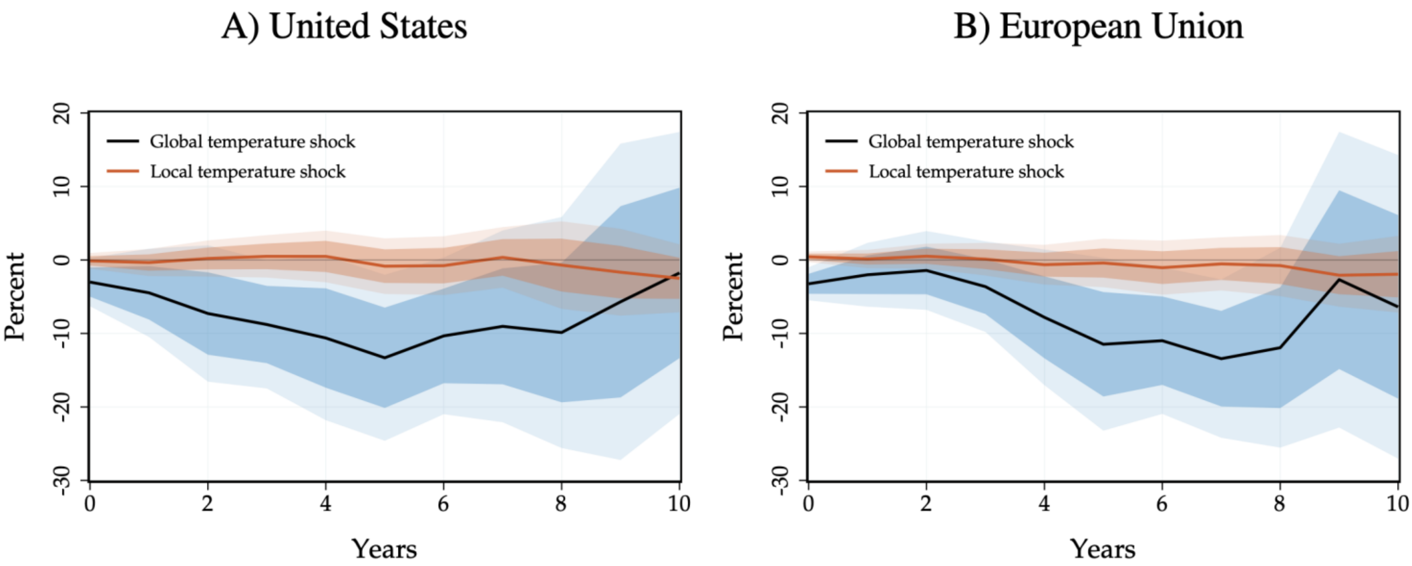
Global versus local temperature effects

Most previous studies have focused on how local temperature changes affect economic output. These analyses typically find relatively modest impacts in the medium run, particularly for advanced economies in temperate regions (Dell et al. 2012, Burke et al. 2015).

Our research takes a different approach: we examine directly how global temperature changes impact national economies, building on Bilal and Känzig (2024). Using natural variability in global mean temperature, we find substantially larger effects than those identified through local temperature changes alone.

Figure 1 displays the effects of a global temperature shock of 1°C. We can see that such warming reduces output per capita by more than 10% at peak in both the US and the EU. These effects are an order of magnitude larger than those estimated using local temperature variation alone.

Figure 1 The effect of global temperature shocks on GDP per capita



***Notes*: Impulse responses of US and EU real GDP per capita to global and local temperature shocks each normalised to 1°C. Sample period: 1960-2019. Solid lines: point estimates. Dark and light shaded areas: 68 and 90% confidence bands.**

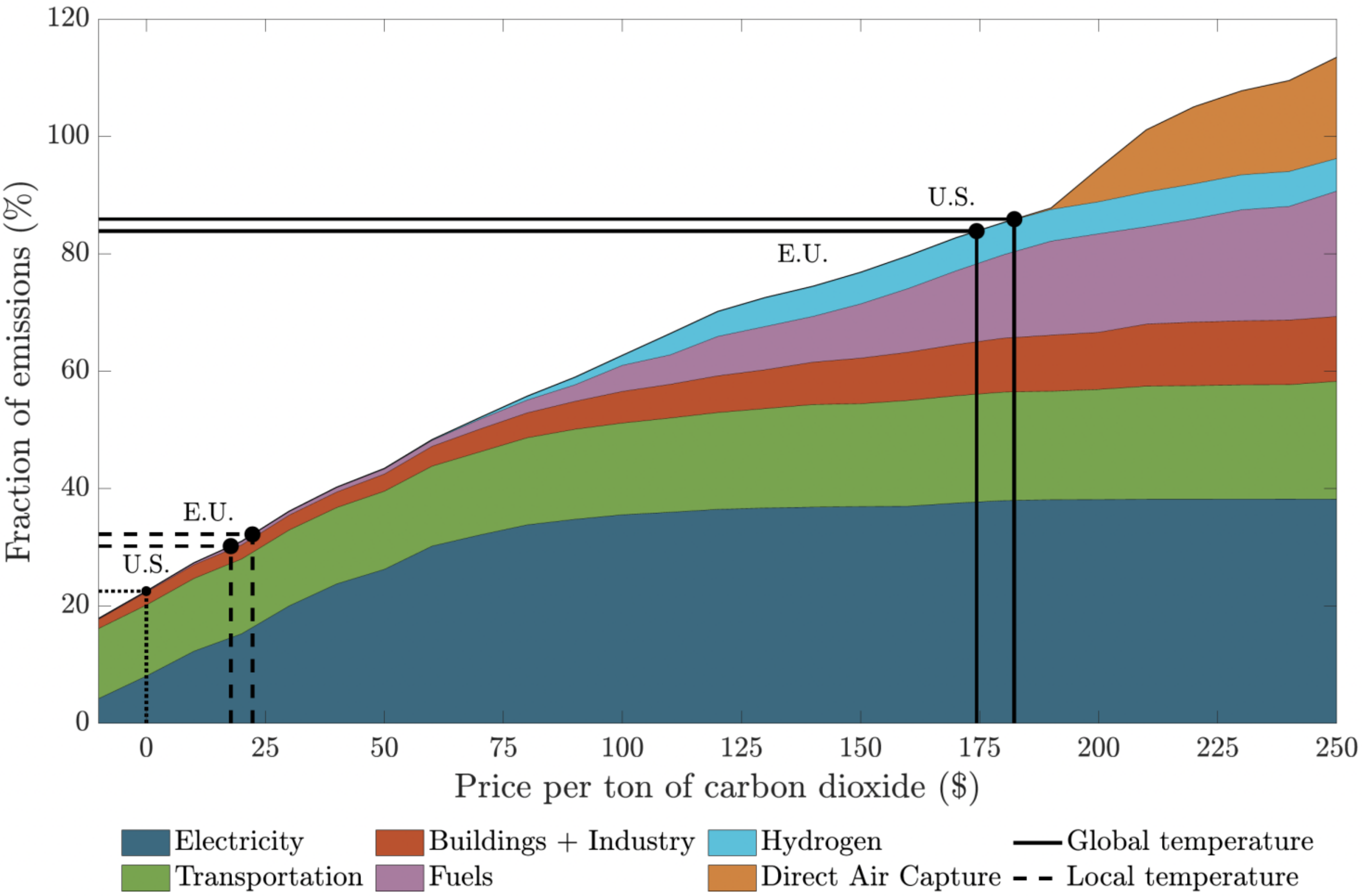
Why such a large difference? Global temperature changes are strongly correlated with extreme weather events like heat waves, droughts, and storms that can severely disrupt economic activity. Local temperature variations, by contrast, have much weaker connections to these damaging events (Bilal and Känzig 2024).

Reassessing costs and benefits

These findings fundamentally alter the cost-benefit analysis of climate action. We estimate an integrated assessment model using our reduced-form evidence on temperature shocks, and find that the domestic cost of carbon – i.e. economic damages *within a given country* from emitting one ton of CO_2 – is over \$170 per ton for the US and the EU. These values are an order of magnitude larger than estimates based on local temperature effects, which are below \$25 per ton.

These economic costs are larger than a wide set of decarbonisation costs under current technologies. Using marginal abatement cost curves from the Environmental Defense Fund (2021), we find that it would be cost-effective for both the US and the EU to unilaterally decarbonise over 80% of their economies by 2050 (see Figure 2). This conclusion includes complete greening of electricity generation and transportation, plus significant progress in building efficiency and industrial processes. By contrast, under conventional damage estimates based on local temperature, optimal unilateral action would achieve only minimal additional decarbonisation beyond what market forces alone would produce.

Figure 2 Cost of carbon versus abatement costs



***Notes*: Marginal abatement cost curve and domestic costs of carbon for the US and the EU. Solid black lines: unilaterally optimal decarbonisation under global temperature damages. Dashed black lines: unilaterally optimal decarbonisation under local temperature damages. Dotted black line: unilateral decarbonisation absent any damages.**

Global temperature impacts thus have profound implications for climate policy. They suggest that major economies may not need to wait for global coordination to take substantial climate action. Domestic benefits alone can justify ambitious decarbonisation efforts.

Concluding remarks

While our findings may reverse conventional unilateral decarbonisation trade-offs, they also come with some qualifications. On the one hand, just as with any empirical estimates, our estimates of temperature impacts necessarily involve uncertainty given the limited time span for which we can study these impacts. However, this uncertainty around sizable point estimates does not lower the incentives to reduce emissions. – quite the contrary. If anything, risk-averse policymakers would undertake broader decarbonisation due to the risk of larger-than-expected damages. Technological progress that improves green technologies would further lower the barriers to broad decarbonisation. On the other hand, equilibrium responses in international fossil fuels prices leading to increased worldwide use could mitigate the effectiveness of unilateral decarbonisation by large economies. We hope that future research will examine and quantify the net effect of these channels.

Regardless of these qualifications, our results do not mean that international coordination is no longer necessary. Smaller economies whose individual emissions influence global temperatures less may still find unilateral action economically unattractive because their domestic cost of carbon scales with the size of their economy. And even for large economies, coordinated action remains more efficient than unilateral efforts. Given new estimates of a worldwide 'social cost of carbon' in excess of $1,300 per ton (Bilal and Känzig 2024), international coordination still has an important role to play.

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