
THE POTENTIAL OF CARBON BORDER ADJUSTMENTS TO FOSTER CLIMATE COOPERATION

WORKING PAPER

Timothé Beaufils^{1, 2, †}, Joschka Wanner^{3, 4, 5}, Leonie Wenz^{1, 5, 6},

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ABSTRACT

We evaluate the potential of the European Union's Carbon Border Adjustment Mechanism (EU CBAM) to foster a climate coalition. Using a general equilibrium quantitative trade model to evaluate the payoffs of a coalition formation game, we find that the EU CBAM motivates the adoption of carbon pricing in four countries. This results in a 73% greater reduction in global emissions compared to a scenario in which only the EU prices carbon, with the coalition-building effect outweighing the direct anti-leakage effect of the CBAM. This effect holds across a broad range of policy designs and modelling assumptions. The size of the induced climate coalition varies strongly with trade elasticities and marginally with input substitutability. Next to the carbon price level, the CBAM implementation plays a decisive role: a CBAM that covers more products or indirect emissions leads to larger coalitions. By contrast, introducing export rebates renders the coalition unattractive.

Keywords Carbon Border Adjustment · Climate policy · International trade · Climate cooperation · Climate clubs

JEL Codes C68; F18; Q56

Highlights

- We combine a quantitative trade model with a climate policy module and a coalition-building game to evaluate policy responses to the EU CBAM
- The EU CBAM reduces carbon leakage in the EU and triggers the adoption of carbon pricing in four other countries: Canada, Japan, South Korea and Taiwan
- This strategic effect quadruples the emission reduction effect of the EU CBAM, increasing global emission reductions by 73% compared to a scenario where only the EU applies the climate policy
- The coalition-building effect of the CBAM is robust across a wide range of modelling assumptions and CBAM designs
- The size of the coalition resulting from the CBAM largely depends on its exact design features (carbon price, product and emission scope)

¹Potsdam Institute for Climate Impact Research, Potsdam, Germany

²Potsdam University, Potsdam, Germany

³University of Würzburg, Würzburg, Germany

⁴Kiel Institute for the World Economy, Kiel, Germany

⁵CESifo

⁶Technical University Berlin, Germany

[†]Corresponding author: timothe.beaufils@pik-potsdam.de

1 Introduction

Since January 1, 2026, exporters of steel, iron, aluminium, cement, fertilisers, electricity, and hydrogen to the EU surrender emission permits at the border of the EU (European Commission, 2023), effectively paying the carbon price imposed on European industries through the European Emission Trading Scheme (EU ETS). The so-called EU Carbon Border Adjustment Mechanism (CBAM) is introduced as an anti-carbon leakage instrument, with the aim of avoiding the relocation of emission-intensive production to countries with less stringent climate policies (Grubb et al., 2022). It is set to substitute the free allowances currently granted to emission-intensive, trade-exposed sectors, which are hardly compatible with net-zero emission targets (Jakob, 2021). From a theoretical point of view, the EU CBAM has the potential to enable the EU to accelerate its climate mitigation effort while protecting its domestic industry from carbon leakage (Böhringer et al., 2022).

While the EU CBAM is introduced as a unilateral policy, it will de facto affect the EU trade partners' policies: not only will it force industries in exporting countries to compete under the EU carbon price, but the EU CBAM gives an incentive to the EU trade partners to implement their own domestic carbon price to collect domestically the fiscal revenue otherwise accruing to the EU (Beaufils et al., 2023b; Otto, 2025). The EU CBAM could thus provide a stepping stone for the bottom-up formation of a coalition of countries implementing climate policies. This paper quantitatively evaluates the conditions under which the EU CBAM triggers the formation of such a climate coalition. To this end, it combines a quantitative trade model with a simple game simulating the formation of a climate coalition.

This article bridges two major trends in the literature, as identified by Overland and Huda (2022). First, a rapidly growing literature assesses the efficiency of the EU CBAM as an anti-carbon leakage instrument. This literature builds on a variety of ex-ante modelling approaches ranging from theoretical (Ambec et al., 2024; Jakob et al., 2013), General Equilibrium (Perdana and Vielle, 2023; Dy and Yang, 2025; Paroussos et al., 2019; Pothén and Hübler, 2018; Ghosh et al., 2012; Hübler, 2012; Bellora and Fontagné, 2023; Larch and Wanner, 2024; Hübler et al., 2025), macro-econometric (Shaw and Fu, 2020) Partial Equilibrium (Chu et al., 2024), or Input-Output (Beaufils et al., 2023b; Zhong and Pei, 2022; Planelles and Sanin, 2025) models. These works overall converge on the potential benefits of CBAMs in terms of reducing carbon leakage (Zhong and Pei, 2024; Böhringer et al., 2022; Sogalla, 2023; Korpar et al., 2022; Böhringer et al., 2012). The expected effects of the EU CBAM are found to largely depend on its exact implementation, both in terms of products and emissions covered (Zhong and Pei, 2024; Beaufils et al., 2023b; Bellora and Fontagné, 2023) and in terms of the carbon price level (Weitzel et al., 2012). Some of these studies evaluate the effect of arbitrary coalitions of countries applying a joint CBAM (e.g. Paroussos et al., 2019; Shaw and Fu, 2020; Weitzel et al., 2012), but do not evaluate how such coalitions would form.

Second, a broad literature corpus investigates self-enforcing international agreements, mostly building on the seminal work of Barrett (1994). While reducing emissions is costly, the benefits from climate mitigation are shared internationally. Each country thus has an incentive to minimise its own contribution while benefiting from the other countries' efforts. To overcome this free-riding risk, Barrett (1994) suggests introducing benefits for mitigating members and penalties for non-abiding countries. In that perspective, Nordhaus (2015) proposes the formation of a climate club (see also Lessmann et al., 2009; Weischer et al., 2012; Hovi et al., 2016), a coalition of countries actively engaging in climate mitigation tied to a reduction of trade barriers between country members and tariffs against non-abiding countries. By relating climate policies with the welfare gains of free trade, a climate club could increase the level of climate action. In the literature, these proposals are evaluated with game theoretical frameworks (Carraro and Siniscalco, 1993; Barrett, 1994) sometimes combined with Integrated Assessment Models (Nordhaus, 2015, 2021; Lessmann et al., 2015; Bourany, 2025) and agent-based models (Sprinz et al., 2018; Núñez-Yebra et al., 2024). This corpus highlights the sensitivity of coalition formation and stability to the exact payoff structure. However, it hinges on uncertain estimates of climate damages, which might lead to bias the coalition potential of climate policies. In addition, this literature systematically relies on reduced-form representations of trade policies to make the coalition-building games tractable, thereby overlooks key features of the real economy, such as the interlinkages between industrial sectors and the general equilibrium effects of trade policies. These shortcomings are particularly relevant in the context of the EU CBAM, for which legal, technical and political limitations strongly constrain the range of possible implementations (Beaufils et al., 2023b; Cosbey et al., 2019; Böhringer et al., 2022) and might thus considerably alter its potential to trigger coalition formation.

This paper brings these two strands of literature together by systematically evaluating the coalition potential of the EU CBAM under consideration of the complex interactions between its trade and strategic effects. It thus contributes to an emerging literature that builds on General Equilibrium (GE) modelling to evaluate the coalition building potentials of carbon border policies (Böhringer et al., 2012; Farrokhi and Lashkaripour, 2025). However, prior work only featured uniform carbon tariffs on embodied fuel emissions. In reality, the EU CBAM will cover a narrow range of products and a specific subset of emissions, a large share of which are not directly associated with fuel combustion (Beaufils

et al., 2023b; Zhong and Pei, 2024)¹. Generally, while it is well-known that the general equilibrium effects of trade and climate policies are sensitive to implementation details, the sensitivity of CBAM-based climate coalitions to alternative implementation options has been overlooked in the related literature (Nordhaus, 2015, 2021; Farrokhi and Lashkaripour, 2025; Bourany, 2025).

This paper addresses this gap by (1) assessing whether the EU CBAM could trigger carbon pricing in other countries under its current setting and (2) evaluating the key features influencing the size and composition of such a climate coalition.

We answer these questions by complementing a quantitative trade model (Caliendo and Parro, 2015) with a rich environmental extension, which we use to evaluate the pay-offs of a dynamic coalition formation game. In comparison with the current state of the literature, our trade model allows modelling the EU CBAM at a high level of precision (product and emission coverage), while capturing the key features of trade and climate policies, such as the diffusion of price effects along supply chains (sector interlinkages), the endogenous trade adjustments and carbon leakage through fuel and competitiveness channels. Our coalition building game builds on myopic, non-cooperative best-response dynamics commonly featured in the related literature and keeps the numerical complexity sufficiently low to evaluate a large range of scenarios in General Equilibrium. Unlike related works, we conservatively exclude the gains from climate mitigation from the coalition formation game and focus on the trade motivations for forming a CBAM-based coalition, thereby providing a lower bound to the coalition potential of the EU CBAM.

We find that, even under conservative assumptions, the EU CBAM suffices to form a modest coalition of countries implementing a carbon price. The emission reduction reached by this coalition largely outweighs the direct emission effect of the EU CBAM and increases by 73% the global abatement level compared to the climate policy in the EU alone. We evaluate the sensitivity of such a coalition to the exact CBAM design (carbon price level, product and emission coverage, export rebates) and to alternative input substitution features (varying trade elasticities and input substitutability). We show that the coalition building effect of the EU CBAM is robust across all specifications, but that the specific coalition resulting from the implementation of the EU CBAM is strongly dependent on the exact CBAM design. Extensions of the EU CBAM to additional sectors and downstream products have the potential to form a larger coalition that would notably also include the US. By contrast, the inclusion of export rebates shrinks the fiscal revenue of carbon pricing, thereby making it unattractive for other countries to join the coalition.

2 Methods and data

Our analysis of the potential effects of the EU CBAM on international cooperation relies on the combination of two modelling steps, drawing respectively from trade economics and game theory. First, we estimate the income and emission effects of different EU CBAM implementation options for the EU and its trade partners. These analyses are conducted using a general equilibrium quantitative trade model, extending Caliendo and Parro (2015) to endogenously evaluate and price fuel and process emissions, which is introduced in Section 2.1. Second, we use counterfactual equilibria evaluated with the quantitative model to compute the pay-offs of a coalition formation game, simulating the policy responses of other countries to the EU CBAM, described in Section 2.2. We provide information on the calibration in Section 2.3.

2.1 A quantitative trade model for evaluating climate policies

The first subsection (2.1.1) introduces the variables used in the model. The second subsection (2.1.2) describes the trade model, mostly taken from Caliendo and Parro (2015). Subsection 2.1.3 describes our extension of the model to evaluate the EU CBAM. Additional notes for implementing the model are provided in the Supplementary Materials (A.1).

2.1.1 Definitions

As a general convention, we indicate the country and sector of origin of the commodities (supplier) with subscripts and the country and sector of destination with superscripts (user). For instance, z_{ir}^{js} denotes the transaction value from sector i in country r to sector j in country s , in basic prices (i.e., excluding taxes, subsidies and intermediate margins)².

¹So-called process emissions are not generated by the combustion of fossil fuels, but by a broad variety of physical and chemical processes, such as cement calcination or iron reduction. Unlike most fuel combustion emissions, these emissions cannot be abated by substituting energy sources, and therefore require specific modelling assumptions (Bednar-Friedl et al., 2012).

²Note that the information on the direction of the transaction is exclusively carried by the superscripts or subscripts, not by the letter: i or j can both indicate the sector of production (as subscript) or of use (as superscript). Similarly, r and s can indicate the country of origin (subscript) or destination (superscript).

We note variables summed over one or multiple dimension(s) by removing the corresponding index/indices. For instance, the value of product i used by sector j in country s is denoted z_i^{js} , with $z_i^{js} = \sum_r z_{ir}^{js}$. We note counterfactual variables with a prime ($'$) and relative changes from baseline values with a hat: if z is the baseline value of a variable, its counterfactual value is denoted by z' and its value relative to the baseline is denoted by $\hat{z}$, with $\hat{z} = \frac{z'}{z}$.

We consider an economic system composed by n countries. In each country, m sectors produce a unique variety, which can be used both for intermediate and final consumption. Indices i or j in country r or s refer to both the products of that sector and the aggregate of firms producing them. We aggregate final consumption (including government expenditures) and investments into a single final demand item per country: y_{ir}^s is the value of good i produced in country r and consumed by final users in country s . We denote the value of the primary inputs bundle used by sector j in country s by V^{js} . While Caliendo and Parro (2015) work with a single primary factor, we follow Caron and Fally (2022) and Mahlkow and Wanner (2023) and assume that value added is composed of a labour input in quantity L^{js} at price v_l^{js} and a natural resource input of quantity N^{js} at price v_n^{js} :

$$V^{js} = v_l^{js} L^{js} + v_n^{js} N^{js}. \quad (1)$$

We denote the ad valorem tax (if larger than 1) or subsidy (if lower than 1) imposed by country s on the use of input i imported from country r by τ_{ir}^s (input tax). Conversely, ζ_{ir}^s is the ad valorem tax or subsidy applied to product i from country r exported to country s (output tax). Note that we use this formalisation for both domestic (i.e. $r = s$) and trade policies (i.e. $r \neq s$).

Baseline expenditures on product i in country s , x_i^s , are given by the sum of the intermediate use of i in s , z_i^s , and of the final use of i in s , y_i^s , in purchaser's prices, i.e. including the taxes and subsidies applied to product i in country s :

$$\begin{aligned} x_i^s &= \sum_r \tau_{ir}^s \zeta_{ir}^s (z_{ir}^s + y_{ir}^s) \\ &= \sum_r \tau_{ir}^s \zeta_{ir}^s x_{ir}^s. \end{aligned} \quad (2)$$

The trade share of country r for supplying product i in country s , π_{ir}^s , is derived from the trade flows in purchaser's prices:

$$\pi_{ir}^s = \frac{x_{ir}^s}{x_i^s}. \quad (3)$$

The share of primary factors in the production function of sector j in country s is denoted γ^{js} and is given by:

$$\gamma^{js} = \frac{V^{js}}{x_{js}^{js}}. \quad (4)$$

The share of labour in the value-added of sector j in country s , μ_l^{js} , is:

$$\mu_l^{js} = \frac{v_l^{js} L^{js}}{V^{js}}, \quad (5)$$

and the share of primary resources in the production function of sector j in country s , μ_n^{js} :

$$\mu_n^{js} = \frac{v_n^{js} N^{js}}{V^{js}}. \quad (6)$$

Finally, the share of intermediate input i in the production function of sector j in country s , γ_i^{js} , is:

$$\gamma_i^{js} = \frac{z_i^{js}}{x_{js}^{js}}, \quad (7)$$

and the final demand consumption share of product i in country s , α_i^s :

$$\alpha_i^s = \frac{y_i^s}{y^s}. \quad (8)$$

2.1.2 Basic trade model

The quantitative trade model largely follows Caliendo and Parro (2015). This is a state-of-the-art quantitative trade model that is used extensively for the evaluation of trade policy scenarios (see e.g. Caliendo and Parro, 2022; Hinz and Monastyrenko, 2022; Chowdhry et al., 2024; Dy and Yang, 2025) and that is concise enough to accommodate the large number of model runs necessary for our analysis. We extend Caliendo and Parro (2015) in three ways. First, we follow Caron and Fally (2022) and Mahlkow and Wanner (2023) and introduce a natural resource primary factor to better capture the supply constraints for fossil fuels. Second, we include a rich climate module that endogenously evaluates the fuel combustion and process emissions embodied in trade. Third, we combine it with a coalition formation game. Therefore, we keep the description of the basic trade model to the essential minimum.

Every country produces one unique differentiated variety in every sector. Producers combine labour, natural resources and intermediates from all sectors in an upper-tier Cobb-Douglas production function³. Intermediate inputs from different countries are combined into a constant elasticity of substitution (CES) input bundle. Consumers buy final products from different countries according to the same CES aggregator. Any trade flow faces iceberg-type trade costs. Firms operate in a perfectly competitive environment, and all goods, labour and natural resource markets are assumed to clear.

Following Dekle et al. (2007, 2008), the equilibrium conditions of the model can be expressed in relative changes, delivering the following, slightly extended representation of the model by Caliendo and Parro (2015) (see Section A.3 in the Supplementary Materials for the full model derivation). This model entails eight base equations introduced in this section (Equations I–VIII). We then extend the model with a detailed carbon accounting and climate policy module, which are introduced in later subsections of the document (Equations IX–XI).

The production cost change in sector j in country s , $\hat{c}_{js}$, depends on the price change of the intermediate inputs i in country s , $\hat{p}_i^s$, and of the primary inputs bundle cost in country s , $\hat{v}^{js4}$:

$$\hat{c}_{js} = (\hat{v}^{js})^{\gamma^{js}} \prod_i (\hat{p}_i^s)^{\gamma_i^{js}}. \quad (I)$$

The price change for input i in country s is derived from the production cost changes in origin countries ($\hat{c}_{ir}$), the input tariffs and subsidy changes ($\hat{\tau}_{ir}^s$), output tariff and subsidy changes ($\hat{\zeta}_{ir}^s$) and sector-specific trade elasticities θ_i ⁵:

$$\hat{p}_i^s = \left(\sum_r \pi_{ir}^s \left(\hat{\tau}_{ir}^s \hat{\zeta}_{ir}^s \hat{c}_{ir} \right)^{-\theta_i} \right)^{-\frac{1}{\theta_i}}. \quad (II)$$

The adjustment of the trade shares ($\hat{\pi}_{ir}^s$) depends on the cost change in exporting country r (including tariffs and subsidies) relative to the price index change in importing country s :

$$\hat{\pi}_{ir}^s = \left(\frac{\hat{\tau}_{ir}^s \hat{\zeta}_{ir}^s \hat{c}_{ir}}{\hat{p}_i^s} \right)^{-\theta_i}. \quad (III)$$

³For the sensitivity analysis presented in Section 3.3, we derive an alternative formulation of the model based on two-tiered Constant Elasticity of Substitution (CES) production functions. The alternative formulation is detailed in Supplementary Materials A.2

⁴When possible, we prioritize keeping the indices consistent with the variables across the key equations of the model. This implies that the indices i and j can denote both, producing (when used as subscripts) or consuming sectors (when used as superscripts). Similarly, indices r and s can code for both origin and destination countries. We remind the reader that the information on the direction of trade flow is here exclusively carried by the use of indices as subscripts (origin/producer) or superscripts (destination/user) - see Section 2.1.1

⁵Note that all equilibrium conditions could easily be expanded to additionally include changes in non-tariff iceberg-type trade frictions, the determinants of which could be estimated using a gravity equation fully consistent with the theoretical framework presented here (see e.g. Pothén and Hübner, 2018).

Note that Caliendo and Parro (2015) derive their model from a Ricardian trade micro-foundation following Eaton and Kortum (2002). In our environmentally extended trade model, this choice affects equilibrium outcomes because process emissions are directly linked to produced physical quantities (see Equation A. 5 in the Supplementary Materials), which do not behave independently of the underlying trade micro-foundation (for a detailed discussion, see Sogalla et al., 2024). Under Eaton and Kortum (2002)-type specifications, firm-level data across countries and sectors would be needed to inform the model about producer-level heterogeneity in emission intensities, which we lack.⁶ Instead, we opt for a Armington (1969)-type model that does not feature heterogeneous producers within a given country-sector combination, and which allows us to treat process emission intensity as constant in real terms (see Section 2.1.3). As both models are part of the subclass of perfectly competitive quantitative trade models, the representation of the trade equilibrium is unaffected by this choice (see Arkolakis et al., 2012).

The counterfactual expenditure on product i in country s , $x_i^{s'}$, is:

$$x_i^{s'} = \sum_j \gamma_i^{js} \sum_r \frac{\hat{\pi}_{js}^r \pi_{js}^r}{\hat{\tau}_{js}^r \tau_{js}^r \hat{\zeta}_{js}^r \zeta_{js}^r} x_j^{r'} + \alpha_i^s y^{s'}, \quad (IV)$$

where α_i^s is country s 's final expenditure share on goods from sector i and $y^{s'}$ is country s 's total counterfactual consumption.

We differ here from Caliendo and Parro (2015) by distinguishing two primary inputs in the value added (V^{js}): labour, at price v_l^{js} , and natural resources, at price v_n^{js} , as done in Caron and Fally (2022) and Mahlkow and Wanner (2023).

The counterfactual final consumption value in country s , $y^{s'}$, is the sum of the labour and natural resource primary inputs' revenues, the net fiscal cost and revenues of input and output tariffs and subsidies (see Equations A. 2 and A. 3 in the Supplementary Materials) and the exogenous trade deficit (d_s):

$$y^{s'} = \hat{v}_l^s v_l^s L^s + \sum_j \hat{v}_n^{js} v_n^{js} N^{js} + \sum_{i,r} (\hat{\tau}_{ir}^s \tau_{ir}^s - 1) \frac{\hat{\pi}_{ir}^s \pi_{ir}^s}{\hat{\tau}_{ir}^s \tau_{ir}^s} x_i^{s'} + \sum_{j,r} (\hat{\zeta}_{js}^r \zeta_{js}^r - 1) \frac{\hat{\pi}_{js}^r \pi_{js}^r}{\hat{\tau}_{js}^r \tau_{js}^r \hat{\zeta}_{js}^r \zeta_{js}^r} x_j^{r'} + d_s. \quad (V)$$

The labour supply is assumed fixed internationally and mobile between sectors, such that the wage change $\hat{v}_l^s$ derives from the economy-wide labour demand:

$$\hat{v}_l^s = \frac{1}{v_l^s L^s} \sum_j \mu_l^{js} \gamma^{js} \sum_r \frac{\hat{\pi}_{js}^r \pi_{js}^r}{\hat{\tau}_{js}^r \tau_{js}^r \hat{\zeta}_{js}^r \zeta_{js}^r} x_j^{r'}. \quad (VI)$$

The natural resource input is also fixed in supply and is only used by the fuel extraction sector. Its factor price change $\hat{v}_n^{js}$ is thereby generally defined by the sector-specific demand for natural resources:

$$\hat{v}_n^{js} = \frac{1}{v_n^{js} N^{js}} \mu_n^{js} \gamma^{js} \sum_r \frac{\hat{\pi}_{js}^r \pi_{js}^r}{\hat{\tau}_{js}^r \tau_{js}^r \hat{\zeta}_{js}^r \zeta_{js}^r} x_j^{r'}. \quad (VII)$$

Finally, the cost of the primary input bundle, $\hat{v}^{js}$ is a Cobb-Douglas combination of the labour $\hat{v}_l^{js}$ and natural resources $\hat{v}_n^{js}$ input price changes:

$$\hat{v}^{js} = (\hat{v}_l^s)^{\mu_l^{js}} (\hat{v}_n^{js})^{\mu_n^{js}}. \quad (VIII)$$

The real income change of country s , $\hat{y}_{real}^s$, is used to compute the payoffs of the coalition formation game described in 2.2 and is derived from combining nominal income changes $\hat{y}^s$ and the change in national price indices p^s :

$$\hat{y}_{real}^{s'} = \frac{\hat{y}^s}{\hat{p}^s}, \quad (9)$$

⁶The same challenge would arise for monopolistically competitive alternatives following Krugman (1980) or Melitz (2003) due to industry-level economies of scale (see Kucheryavyy et al., 2023). For the latter, results would additionally differ because tariffs affect the productivity cut-off at which firms find it profitable to select into exporting (see Sogalla, 2023). Balistreri et al. (2025) show that Melitz-type specifications yield larger trade effects than the Armington-type used in this study.

where the national price index changes are defined as:

$$\widehat{p}^s = \prod_i \left(\widehat{p}_i^s \right)^{\alpha_i^s}. \quad (10)$$

2.1.3 Climate policy module

We model the climate policy as the combination of a Domestic Carbon Price (DCP), Import Adjustments (IA) and Export Rebates (ER). The DCP applied is modelled as a domestic input tax on fossil fuel use (denoted $(\widehat{\tau}_f^s)_{ir}$) and a domestic output tax on process emissions ($(\widehat{\zeta}_p^s)_{ir}$). IA are input tariffs applied by country s on imports of commodity i from country r , $(\widehat{\tau}_{ia}^s)_{ir}$. ER are output subsidies that compensate the cost of the DCP and IA on exported products, $(\widehat{\zeta}_{er}^s)_{ir}$. Taxes, tariffs and subsidies are defined as ad valorem rates and associated with domestic lump-sum transfers (see Equation V). Emission intensities are kept constant in real terms, but the ad valorem rates and the embedded emissions are endogenously updated when solving the model (Equations IX to XI)⁷.

Ad valorem emission intensities Our model distinguishes between CO₂ emissions from the combustion of fuels and process emissions. Fuel combustion emissions correspond to energetic uses and can relatively easily be replaced by alternative or more efficient energy sources, using existing technologies. Instead, process emissions are associated with electrochemical reactions that can hardly be mitigated with current technologies (Bednar-Friedl et al., 2012). While process emissions represent only about 10% of the total emissions (Gütschow et al., 2021b), this rate is higher for the sectors covered by the EU CBAM: 34% for aluminium, 45% for iron and steel and 50% for cement production (Gütschow et al., 2021b). Here, we model the fuel combustion emissions proportional to the quantity of fuel used and the process emissions proportional to the output quantity: industries can reduce their fuel emissions by limiting their use of fossil fuels, but process emissions can only be abated by reducing the output volume.

We denote the real emission intensity of using a fixed quantity of fuel i by $\bar{e}_i$ - which we assume constant across time and space - and the emission intensity per monetary unit of the fuel i used in country s by e_i^s . For a given fuel price level p_i^s , the real and nominal intensities are related by the following equation:

$$e_i^s = \frac{\bar{e}_i}{p_i^s}. \quad (11)$$

It follows that, in the counterfactual equilibrium, the ad valorem carbon intensity of burning fuel i in country s , e_i^s , is proportional to the inverse of the price index change of the fuel i in that country, $\widehat{p}_i^s$:

$$e_i'^s = \frac{e_i^s}{\widehat{p}_i^s} \quad (12)$$

Similarly, we denote as ϵ_{ir} the emissions embodied in one unit of product i produced in country r . Following our Armington-type trade structure (Armington, 1969), the counterfactual ad valorem emission intensity of the imports of a monetary unit of product i produced in country r and used in country s , $\epsilon_{ir}'^s$, is linked to the price of product i in importing country s , $\widehat{p}_i^s$:

$$\epsilon_{ir}'^s = \frac{\epsilon_{ir}}{\widehat{p}_i^s}. \quad (13)$$

As for fuel emissions, the real process emission intensity relates to the production of product i in country r , $\bar{e}_{ir}$, assumed constant. We denote by e_{ir} the baseline nominal emission intensity, per value unit:

$$e_{ir} = \frac{\bar{e}_{ir}}{c_{ir}}. \quad (14)$$

The counterfactual nominal intensity of process emissions ($e_{ir}'^s$) derives from the baseline emission intensities e_{ir} and the cost change $\widehat{c}_{ir}$:

⁷The endogenous updating of emissions intensities based on current price and cost levels is similar to the extension of Caliendo and Parro (2015) by Dy and Yang (2025). However, Dy and Yang (2025) model all emissions as unavoidable by-products of production processes. In our model, this is only the case for process emissions. Fuel combustion emissions can be reduced by substituting fossil fuel inputs with alternative inputs.

$$e'_{ir} = \frac{e_{ir}}{\widehat{c}_{ir}}. \quad (15)$$

Policy layers Given a carbon price level λ'_r , country r can apply an ad valorem tax on the use of fuel i , $(\widehat{\tau}_f)_i^r$, on the domestic process emissions i , $(\widehat{\zeta}_p)_{ir}$, and on the emissions embodied in the imports of product i from country s (import adjustment, $(\widehat{\tau}_{ia})_{is}^r$). Using the notations previously introduced, the three components are defined as:

$$\begin{cases} (\widehat{\tau}_f)_{is}^r &= \left(1 + \lambda'_r \frac{e_{ir}^r}{\widehat{p}_i^r}\right); \\ (\widehat{\tau}_{ia})_{is}^r &= \left(1 + \lambda'_r \frac{e_{is}^r}{\widehat{p}_i^r}\right); \\ (\widehat{\zeta}_p)_{ir}^s &= \left(1 + \lambda'_r \frac{e_{ir}}{\widehat{c}_{ir}}\right). \end{cases} \quad (IX)$$

Rebates Additionally, country r can introduce export rebates to compensate for the effect of the climate policy on the exported production of regulated sectors. We denote again by ϵ_{ir} the (nominal) emission intensity embodied in the production of one unit of output from the sector i of country r .

The cost-effect of the climate policy on the production of i in country r is proportional to the value of carbon tax paid on indirect emissions, $\lambda'_r \frac{\epsilon_{ir}}{\widehat{c}_{ir}}$. Under this assumption, the rebates that compensate the indirect cost of the climate policy on exports to country s , $(\widehat{\zeta}_{er})_{ir}^s$, are:

$$(\widehat{\zeta}_{er})_{ir}^s = \left(1 + \lambda'_r \frac{\epsilon_{ir}}{\widehat{c}_{ir}}\right)^{-1}. \quad (X)$$

Composition of the tariffs and subsidies layers The domestic fuel tax $(\widehat{\tau}_f)_i^r$ and the import adjustments $(\widehat{\tau}_{ia})_{is}^r$ apply to inputs used in production processes, while the domestic process tax $(\widehat{\zeta}_p)_{ir}$ and the export rebates $(\widehat{\zeta}_{er})_{ir}^s$ apply to production outputs. The resulting input policy layer applied by country r on the use of product i from country s in country r , $\widehat{\tau}_{is}^r$, and the output policy layers applied on products i from r and used in country s , $\widehat{\zeta}_{ir}^s$, are defined as the multiplication of the respective input and output policy layers:

$$\begin{cases} \widehat{\tau}_{is}^r &= (\widehat{\tau}_f)_i^r (\widehat{\tau}_{ia})_{is}^r \\ \widehat{\zeta}_{ir}^s &= (\widehat{\zeta}_p)_{ir} (\widehat{\zeta}_{er})_{ir}^s. \end{cases} \quad (XI)$$

Sectoral coverage The different layers of the climate policies may cover a subset $\bar{J}$ of sectors only. In the case of output layers (process tax and export rebates, respectively), the layer selectively applies to this subset of sectors, $\bar{J}$, by setting the process tax to non-covered sectors $\bar{J}$ to 1. The input layers (import adjustments and fuel tax) apply to all the products i used in country r , without discriminating between the sectors using these inputs. In the case of import adjustments, it is reasonable to assume that the border adjustment applies to all imported products, without discriminating against the actual user of such products. However, applying the domestic fuel tax to a selected subset of sectors only requires introducing a regulated fuel sector, which supplies to the subset $\bar{J}$. The characteristics of such a regulated fuel sector are detailed in the Supplementary Materials (A.4).

Embodied emissions The computation of the embodied emissions in products traded from/to the countries applying the climate policy to/from the unregulated countries depends on the number of supply chain layers considered. Following usual emission accounting conventions, fuel and process emissions are propagated along the supply chains in proportion to the transaction values, in basic prices (Beaufils et al., 2023a). The technicalities of the embodied emissions accounting module are discussed in the Supplementary Materials (A.5).

2.2 Coalition formation game

We model the formation of a climate coalition as a finite dynamic game with bounded rationality. At each stage of the game, we evaluate for each player the pay-off profile associated with the decision to apply or not apply the climate policy using the quantitative trade model introduced in Section 2.1.2 and taking the current coalition as given. The countries then form a coalition for the next stage by simultaneously playing their best-response move to the current coalition. If the new coalition is different to all the coalitions formed in earlier stages of the game, the stage-game is

repeated: the pay-off profiles are re-evaluated, and countries play their best-response move to the new coalition. The stage-game is repeated until the players face a coalition already played in a previous stage. A repeated coalition is *stable* in the sense of Carraro and Siniscalco (1993) if it is played in two consecutive stages of the game.

Due to the numerical complexity of evaluating the pay-off profiles,⁸ we assume myopic and non-cooperative decisions: countries do not form beliefs on future stages of the game and do not make joint decisions. We also shrink the option space to a binary choice: countries either do nothing or implement the exact same policy as EU countries (an exogenous carbon price on a selection of sectors corresponding to the EU ETS and a CBAM on countries outside the coalition). These features are critically discussed in Section 4.3 of the paper.

Formally, we denote by N the set of all countries and Ω_n the climate coalition at the n -th stage of the game, i.e., the set of countries applying the climate policy. $W(\Omega_n)$ is the pay-off profile of that coalition, i.e., the vector of real income changes derived from the quantitative trade model (Equation 9).

Ω_n^{-r} indicates the climate coalition at the n -th stage of the game *in the absence of* a country r : if r is part of the coalition at stage n , Ω_n^{-r} equals the coalition of that stage without the country r , $\Omega_n/\{r\}$; otherwise, Ω_n^{-r} is the same as the coalition of the stage, Ω_n . At stage $n + 1$, each country evaluates its conditional real income for being part of the coalition ($W_r(\Omega_n^{-r} \cup \{r\})$) and being outside the coalition ($W_r(\Omega_n^{-r})$), taking the state of the existing coalition, Ω_n^{-r} , as given. Based on their individual pay-off profile, all countries (including those already part of the coalition at stage n) simultaneously play their best response to the existing coalition. The coalition resulting from the stage $n + 1$, Ω_{n+1} , is then the set of countries deciding to apply the climate policy:

$$\Omega_{n+1} = \{r \in N | W_r(\Omega_n^{-r} \cup \{r\}) > W_r(\Omega_n^{-r})\}. \quad (16)$$

In case of equality ($W_r(\Omega_n^{-r} \cup \{r\}) = W_r(\Omega_n^{-r})$), we assume that the country r decides not to apply the climate policy at stage $n + 1$.

The game stops after k stages, where a coalition of the game is first repeated:

$$\exists n < k, \Omega_n = \Omega_k. \quad (17)$$

The recursive rule of the game (Equation 16) and the pay-off structure (evaluated for each possible decision using the quantitative trade model introduced in Section 2.1.2) are fully deterministic. Thus, the coalition resulting from the stage reaching the stopping criterion can have two interpretations:

1. If the same coalition emerges from two successive stages ($n = k - 1$), the final coalition Ω_k corresponds to a Nash equilibrium of the final stage⁹ and the coalition is stable internally and externally in the sense of Carraro and Siniscalco (1993): at stage $k - 1$, the countries inside (outside) the coalition confirm that staying within (outside of) the coalition is their best option given the current coalition.
2. If the same coalition does not emerge from successive stages ($\Omega_k \neq \Omega_{k-1}$), the coalition is unstable: since each stage of the game is deterministic, this situation corresponds to a circular outcome of the game.¹⁰ Still, this outcome does not preclude the existence of a smaller stable coalition, which we determine by forcing the unstable countries outside of the coalition.

2.3 Data, implementation and calibration

The model is calibrated using Multi-Regional Input-Output (MRIO) data from the World Input-Output Database (WIOD) 2016 release, for the year 2014 (Timmer et al., 2015). The database distinguishes between 56 sectors and

⁸The challenge of the numerical complexity of coalition formation is well known from the related literature (Farrokhi and Lashkaripour, 2025; Nordhaus, 2015, 2021; Bourany, 2025). With 14 players, a systematic evaluation of all possible coalitions implies the computation $2^{14} = 16384$ equilibria. While such computation is not out of the reach of modern computing capacities, the game we define here only requires the evaluation of the subset of *relevant* coalitions accessible given the rules of the game - less than 30 unique equilibria in the main scenario (see Figure 3). This allows the exploration of a broader range of scenarios (see Sections 3.2 and 3.3) and simplifies the interpretation of the results.

⁹Note that, given the absence of foresight, the final coalition is not necessarily a Nash equilibrium of the full game.

¹⁰Such a situation typically occurs when a country A benefits from applying the policy as long as another country B does not, while the other country B does only benefit from applying the policy if the other country A applies it, too. In this situation, if country A decides to join the coalition at a first stage of the game, country B joins it in the second stage, which causes country A to leave in the third stage, causing country B to leave in the fourth stage, which ultimately reverts to the situation in the first stage of the game. See Figure C.6 in the Supplementary Materials for an illustration of such a situation.

covers 43 countries and one Rest of the World (RoW) region. The shares of natural resource rents in the fuel extraction sector are obtained from the Global Trade Analysis Project (GTAP) data, version 11c (Aguiar et al., 2022). We take the trade elasticities from Fontagné et al. (2022), estimated at the product level from tariff shocks between 2001 and 2016 in a structural gravity model, aggregated at the sector level and reported in Table D. 1. Emission intensities are derived from the PRIMAP databases (Gütschow et al., 2021b,a) using the Multi-Scale Mapping method described in Beaufils et al. (2023a). Additional notes on the calibration of emission intensities are provided in the Supplementary Materials (A.6). The corresponding mapping table is provided in the Supplementary Materials (Table D. 2).

The quantitative trade model is solved using a fixed-point resolution algorithm. Both the trade model and the coalition formation game are implemented in Python and available in the reproduction package of the article.¹¹

We represent the EU ETS as a fixed carbon price of 100 USD per tCO₂, applied to all CO₂ emissions from emission-intensive sectors (see Table D. 3 in the Supplementary Materials). For simplicity, we do not model the free allowances in the baseline ETS scenarios. The EU CBAM is modelled as a tariff on the imports of a selection of products (see Table D. 4), whose rate is proportional to a selected subset of embodied emissions (see Table D. 5 for the set of emissions and D. 6 for the ad-valorem tariff rates in the baseline equilibrium). The Export Rebates are calibrated according to Equation X to compensate the carbon price paid by the exporters of the same CBAM sectors (Table D. 4), on their direct emissions (Table D. 5).

Beyond the 27 EU member states, we assume that the EU climate policy also applies to the non-EU signatory members of the EU ETS (Switzerland, Norway, Iceland), as announced in the EU CBAM implementation act (European Commission, 2023). We also include the United Kingdom (UK) as a member, since the UK already announced its willingness to re-couple its ETS with the EU ETS, while applying a similar CBAM (Department for Energy Security, 2023). For simplicity, we refer to all these countries as the "EU" region. Some countries outside this EU region have an ETS in place, which should in principle be taken into account for computing the CBAM adjustment (World Bank, 2024). However, these ETS are either applied at the subnational level (Quebec, California) or have a relatively low price (Korea, China). We also assume that the EU region commits to its climate policy unconditionally and that the ROW region lacks the political cohesion to implement a climate policy.

3 Results

In the following section, we apply the modelling framework introduced in Section 2 to assess the effects of the EU CBAM on emission reductions and income levels, both within and outside the EU, as well as its potential to trigger the formation of a climate coalition. The first section (3.1) focusses on our main scenario that mirrors the current EU CBAM implementation design to uncover the key mechanisms driving the trade and strategic effects of the EU CBAM. The second section (3.2) assesses how the coalition building potential of the EU CBAM varies with different CBAM designs. The third section (3.3) evaluates the sensitivity of these effects to alternative assumptions on input substitutability.

3.1 Main scenario

This section evaluates the effects of the EU CBAM as currently planned. The first part of the analysis omits the policy responses of trade partners and only uses the trade model described in 2.1 to highlight the key economic mechanisms at play. The second part endogenises the policy responses of other countries using the coalition formation game presented in 2.2.

3.1.1 Static analysis

Figure 1 shows the income and emission effects of an EU ETS without any anti-leakage instrument (green dots) and an EU ETS combined with the EU CBAM (orange triangles). In the absence of an anti-leakage instrument, the EU ETS reduces emissions in the EU by 14%. The emission reduction comes at a moderate cost, with a 0.05% reduction of the aggregated EU real income.

In turn, the EU ETS causes emission increases in the rest of the world. For most of the trade partners, the EU ETS has a negligible effect on real incomes (below 0.05%), except for Russia and Türkiye.¹² The EU climate policy impacts trade partners through two main channels, which both contribute to increasing emissions in non-EU countries (see

¹¹<http://doi.org/10.5281/zenodo.17573732>.

¹²Note that we calibrate the model to a baseline equilibrium before the Russian attack on Ukraine. The war and Western trade sanctions have led to a reduction in trade between the EU and Russia, which will make Russia less directly affected by EU climate policy.

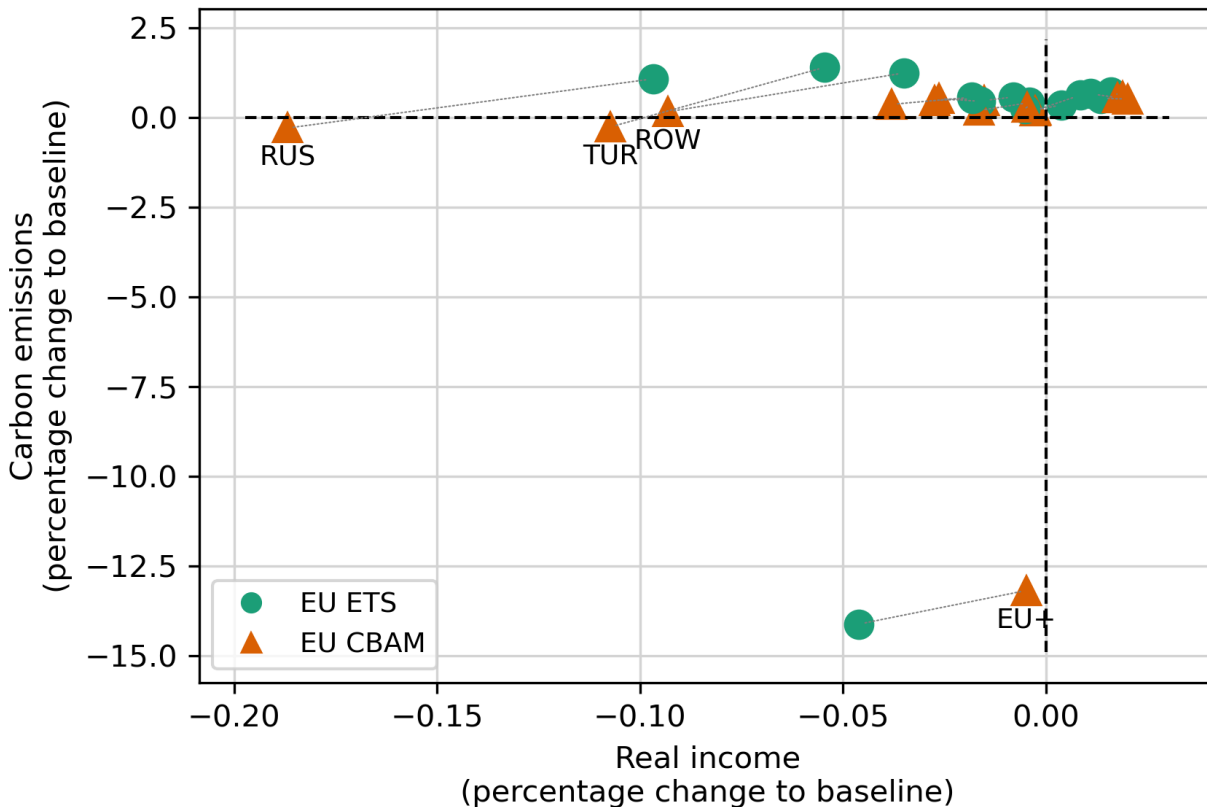


Figure 1: **Assessment of the impact of the EU ETS and EU CBAM on emission and income levels.** The green dots figure the income (x-axis) and emission effects (y-axis) of applying a carbon price of 100 USD per tCO₂ on the EU industrial emissions (EU ETS scenario). The orange triangles correspond to a policy combining this carbon price with a CBAM applied to imports to the EU. The results are provided in percentage deviation from the baseline equilibrium, in which no ETS nor CBAM are implemented.

Figure C.1 in the Supplementary Materials). First, the EU climate policy reduces the global fuel demand, which reduces the incomes of fuel exporting countries (Russia, Rest of the World - ROW) and marginally benefits fuel importing countries (e.g., China, India, Japan). Second, the ETS increases the price of emission-intense goods produced in the EU (basic metals, chemicals, non-metallic minerals), which causes an increase in imports to and a reduction of exports from the EU. In reaction, exporters to the EU increase their production, while consumption prices rise in importing countries. In the EU, the aggregated price index change is negligible, and the negative effect of the wage losses is mostly compensated by the ETS fiscal revenue. In Türkiye, the price index change exceeds the wage increase, and the absence of fiscal revenue explains the relatively high real income impact (see Figure C.2 in the Supplementary Materials).

The introduction of the EU CBAM (orange triangles) has a negligible effect on the EU emissions and a positive effect on the EU real income compared to the EU ETS alone. The EU CBAM impact is qualitatively homogeneous for all trade partners, with a simultaneous decrease in emissions and income (EU CBAM data points for the trade partners are on the lower left of the comparable EU ETS Figures). By levelling the playing field for the CBAM products, the EU CBAM reduces the gains from leakage for the EU trade partners. Again, the impact of the EU CBAM is stronger for close trade partners, such as Türkiye and Russia. In both countries, the losses are driven by a decreasing demand from the EU for fossil fuels and CBAM products (see Figure C.3, Supplementary Materials).

In quantitative terms, the EU ETS reduces by 505 Mt the CO₂ emissions in the EU (Figure 2, panel A). Such emission decrease is partially offset by emission increases in other countries, mainly driven by China and the Rest of the World (ROW), such that the overall emission reduction is only 305 MtCO₂. We estimate a carbon leakage rate of 40%, as the ratio between the emission level increase for trade partners and the reduction in the EU.

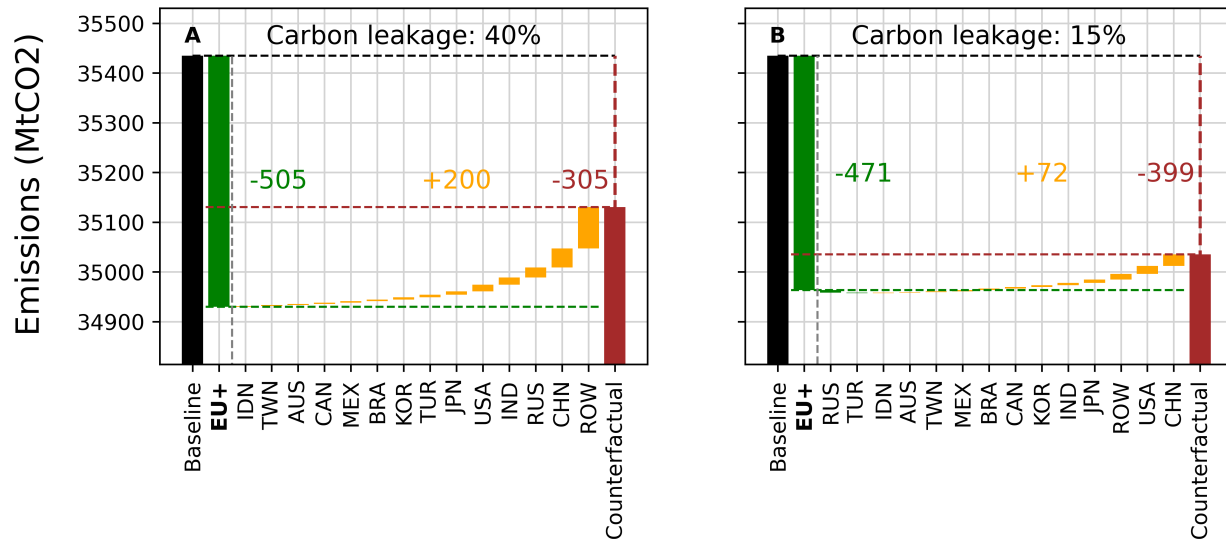


Figure 2: **Comparative contributions to emission reductions under an EU ETS (panel A) and an EU ETS combined with a CBAM (panel B).** The black, left bar shows the global volume of CO₂ emissions in the baseline scenario, i.e., without the ETS and the CBAM being implemented. The red bar on the right shows the global emissions in the counterfactual scenario, i.e. with the climate policy being applied. The bars show the contribution of each individual country to the difference in emissions between the baseline and counterfactual scenario. Green bars show emission reductions and orange bars show emission increases. The ratio between the emission reduction in the EU (green annotation) and the emission increase in the rest of the world (orange annotation) corresponds to the carbon leakage.

In comparison to the EU ETS scenario, the EU CBAM leads to a slightly smaller reduction of CO₂ emissions in the EU (471 MtCO₂ instead of 505 MtCO₂). At the same carbon price, EU emissions could previously be partly reduced by pushing emission-intensive production abroad and importing the respective goods back into the EU (see Figure C.3 in the Supplementary Materials). With a CBAM in place, more of the emission-intensive production remains in the EU, leading to higher EU emissions. However, the reduction of the leakage effect from 40% to 15% leads to a global emission reduction that is 94 MtCO₂ higher than with the EU ETS alone (399 MtCO₂ instead of 305 MtCO₂, Figure 2, panel B). There are two key reasons why a CBAM can be expected to reduce rather than eliminate leakage. First, it only levels the playing field within the EU market. In export markets, EU producers still face a competitive disadvantage due to the EU ETS carbon price. Such "export leakage" is reinforced by the indirect price increase for the secondary manufacturing sectors (e.g., vehicles, machinery), which face higher input costs in the EU (Figure C.3, Supplementary Materials). Second, a CBAM does not directly tackle carbon leakage via international energy markets: lower EU demand for fossil fuels lowers international fuel prices and hence drives up fuel demand (and emissions) outside the EU. Our finding of the CBAM lowering leakage without bringing it down to zero is consistent with other recent contributions in the literature (see e.g. Sogalla, 2023; Korpar et al., 2022).

While the EU CBAM extends the coverage of the EU carbon price to polluters in non-EU countries, the fiscal revenues of the EU CBAM are recycled within the EU (Figure C.2, Supplementary Materials). If the EU trade partners were to implement their own carbon pricing policy, they would be exempt from the EU CBAM and could retain the fiscal revenue of the carbon tax for domestic use. In the next section, we evaluate whether the EU CBAM could motivate the formation of a climate coalition beyond the EU.

3.1.2 Strategic responses to the EU CBAM

Figure 3 pictures the coalition-building game introduced in Section 2.2. Each panel of the Figure describes the successive conditional decisions of the corresponding country. In each step, countries compare the potential outcome of joining the coalition (applying the EU ETS policy and a respective CBAM on non-coalition countries, green dot) to the option of staying neutral (orange cross) and take the decision that would yield the largest income. We assume that countries make myopic decisions. They know which countries have announced their intention to apply the policy in the previous stage and assume that these intentions will not change in the current stage. The black markers show

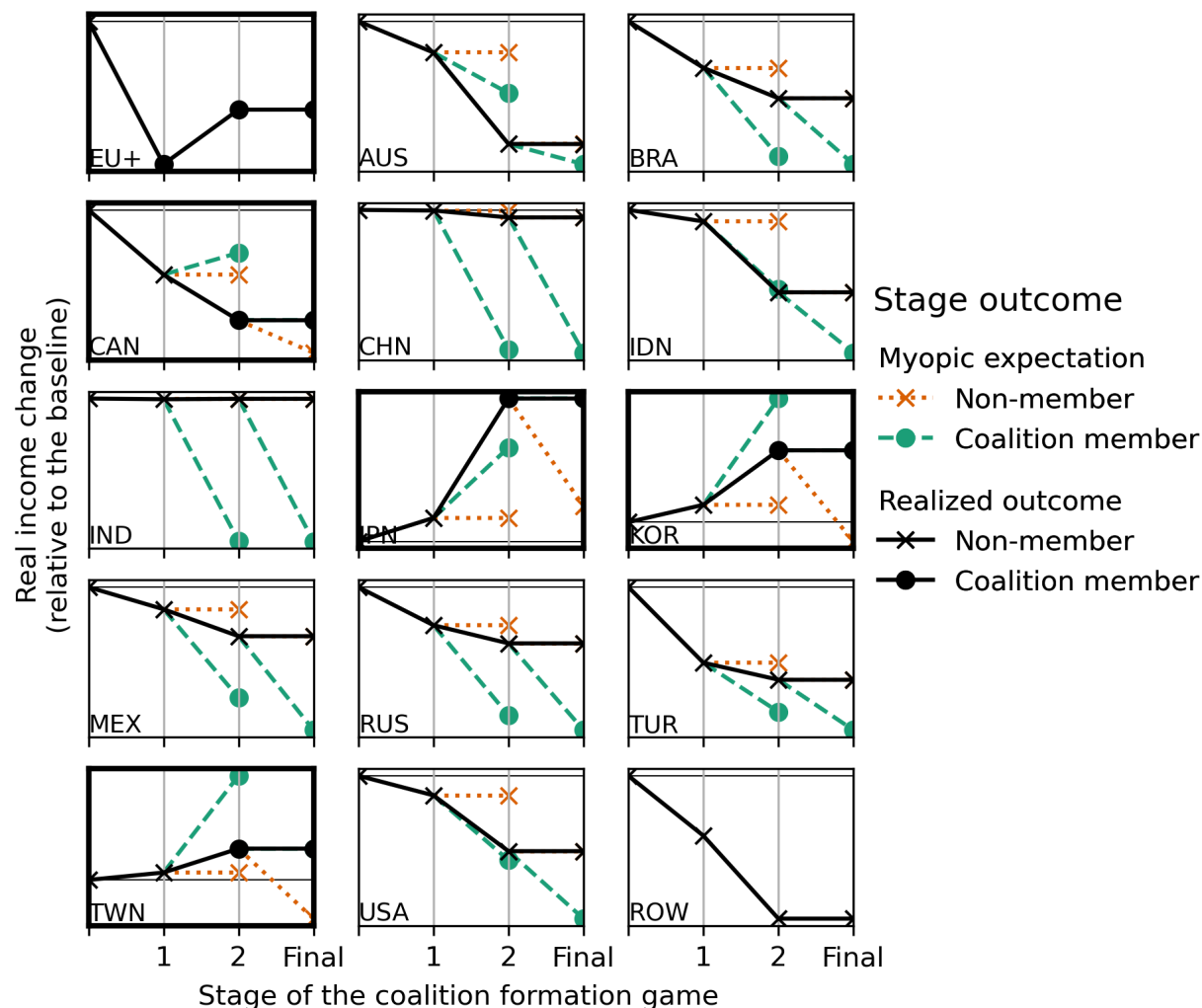


Figure 3: **Formation process of the climate coalition in the main scenario.** Panels show the stages of the coalition formation game for the individual countries and the "rest of the world (RoW)" region (x-axis). On each panel, the y-axis represents the relative income effect, evaluated in each conditional state using the trade model described in Section 2.1.2. For clarity, we here omit the numerical values on the y-axis: the outcome of the coalition formation game only depends on the ordinal ranking of options at each stage - see equation 16. At a given stage of the game (indicated by a vertical line on the x-axis), all countries have either no climate policy implemented (black crosses) or apply a 100 USD/tCO₂ carbon tax on ETS sectors and a CBAM on non-coalition countries (black dots). For the next stage of the game, all countries (except for the EU, which is assumed to commit to its climate policy - and for the ROW region, which is assumed not to have the required political homogeneity to implement a climate policy) evaluate their hypothetical pay-off from having no climate policy (orange crosses) or from implementing the climate policy and *de facto* joining the climate coalition from the previous stage of the game (green dots). Countries simultaneously play their best response, i.e., choose the option yielding the largest expected income (y-axis), taking the other countries' decisions as given. This choice is denoted in black for the next stage of the game. Because the countries do not anticipate the moves of other players and take myopic decisions - see Section 2.2 -, the income realizations at the next stage of the game do not necessarily match the expectation formed at the previous stage. The game is played until a stage results in an already played coalition. This is the case in stage 3, which results in the same outcome as stage 2. The countries applying the policy in this final stage are denoted by a thicker frame.

the countries' relative real income once all the moves from the previous stages are simultaneously applied. Note that these realisations often differ from the respective coloured expectations: the assumption that other countries would not change their intention is violated as soon as any other country decides to change its stance on the coalition, thus creating a mismatch between a country's pay-off expectations (coloured lines and markers) and the actual realisation (black lines and markers).

For instance, in the first stage of the game, Canada suffers income losses due to the EU CBAM (first panel of the second row, stage 1, black cross). Canada then evaluates the cost of implementing its own ETS with a CBAM (stage 2, green dot) and compares it to the cost of doing nothing (stage 2, orange cross). Here, the implementation of the climate policy is income-improving for Canada,¹³ which therefore joins the coalition in stage 2. In the meantime, Japan, Korea and Taiwan also evaluate the implementation of an ETS and a CBAM to be income-improving. At the start of the second stage of the game, the EU, Canada, Japan, Korea and Taiwan simultaneously opt for implementing the climate policy and form a *de facto* climate coalition. However, because the countries did not anticipate the simultaneous decision of the other players, the income realisation of this coalition (black dot, second stage) differs from the expected income (green dot, second stage).

The stage game is thus repeated, this time taking as given a climate coalition formed of the EU, Canada, Japan, Korea and Taiwan. The countries outside of the coalition evaluate whether they would benefit from joining the coalition themselves (stage 3, green dots) in comparison to doing nothing (stage 3, orange dots). Likewise, the countries within the coalition evaluate again whether the expected income from staying within the current coalition (green dots) exceeds the expected income from defecting (orange dots).

With the specifications of our main scenario, all the countries confirm in the second stage the moves they played in the first stage: the countries in the coalition choose to commit to the climate policy (internal stability), and the countries outside of the coalition confirm that they would not benefit from joining the coalition formed in the first stage (external stability). The coalition formed by the EU, Canada, Japan, Korea and Taiwan is thus stable in the sense of Carraro and Siniscalco (1993).

The coalition induced by the EU CBAM leads to an overall 691 MtCO₂ emission reduction (Figure 4). While the abatement level within the EU stays comparable to the scenario neglecting the response from trade partners (455 MtCO₂, compared with 471 MtCO₂ in Figure 2), Canada, Japan, Korea and Taiwan applying the EU climate policy leads to an additional 498 MtCO₂ in global emission abatement. From the EU perspective, this additional effect corresponds to a *negative carbon leakage* of -73%. Compared to the direct anti-leakage effect of the EU CBAM when applied in the EU only (93 MtCO₂, compare Panel A and B in Figure 2), accounting for the adoption of carbon pricing in other countries quadruples the effect of the EU CBAM on global emissions.

Finally, the coalition-level emission leakage is higher (28%) as in the scenario without endogenous policy responses (15%, Figure 2): in the unilateral EU policy case, most emissions leak to China, the USA and the ROW aggregate. Once Canada, Japan, Korea, and Taiwan join the coalition, the largest leak of carbon emissions flows into China - an intuitive shift given the new East Asian focus of the larger coalition.

3.2 Alternative CBAM designs

In this section, we evaluate how the formation of a CBAM-based climate coalition depends on its design. First, we evaluate the integration of different product and emission scopes (Section 3.2.1). Second, we assess the role of the carbon price level (Section 3.2.2).

3.2.1 CBAM extensions

In this section, we evaluate four potential extensions of the EU CBAM. First, we consider the extension of the EU CBAM to a larger number of products: we define a *wide* CBAM that entails the direct emissions related to imported products from all ETS sectors. Second, we evaluate a *deep* extension of the EU CBAM, which is an EU CBAM that accounts for all upstream emissions embodied in the imported products currently covered by the EU CBAM. Third, we consider a *comprehensive* CBAM, which combines the product coverage of the *wide* CBAM and the emission coverage of the *deep* CBAM, i.e., all upstream emissions from all ETS industries imported to the EU. Fourth, we evaluate the

¹³The reduction of the global fuel demand depresses fuel prices, thereby reducing primary incomes for fuel exporters, among which Canada. In turn, cheaper primary factors make the Canadian economy relatively more productive in labour-intensive, emission-scarce goods and services. This terms-of-trade effect makes the implementation of the ETS and the CBAM relatively low-cost in Canada (see Figure C.4 in the Supplementary Materials and Section 3.3.2 on the role of substitution between wages and natural resources). Furthermore, the carbon price only applies at the point where fossil fuels are burned (see Section 2.1.3): the fossil fuel exports from Canada are thus mostly unaffected by the Canadian climate policy (Figure C.5 in the Supplementary Materials).

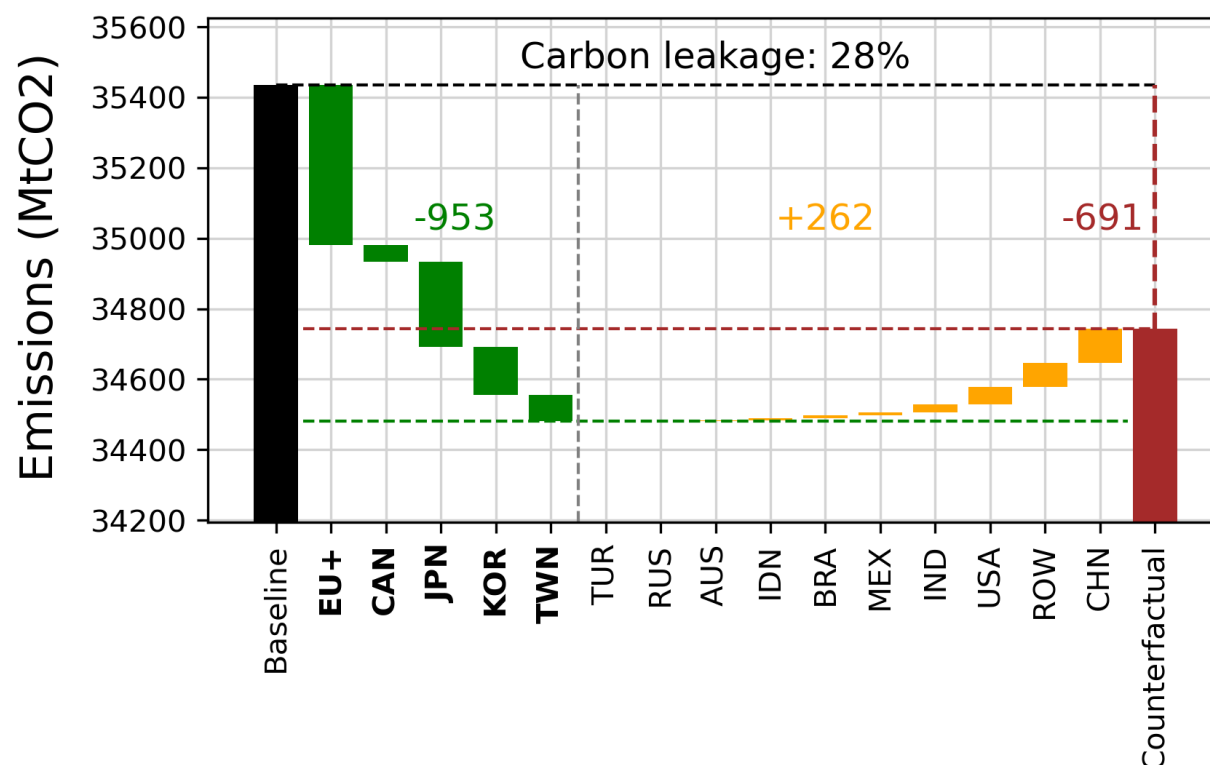


Figure 4: **Comparative contributions to climate change mitigation under an EU CBAM-induced climate coalition.** The red bar on the right shows the global emissions in the counterfactual scenario, i.e., with an ETS and a CBAM applied in the EU, Canada, Japan, Korea and Taiwan. The black bar denotes the emissions in the baseline scenario, i.e., without any ETS or CBAM in place. The bars show the contribution of each individual country to the difference in emissions between the baseline and counterfactual scenario. Green bars show emission reductions and orange bars show emission increases. The ratio between the emission reduction in the countries applying the climate policy (left of the grey vertical dashed line, value in green) and the emission increase in the rest of the world (value in orange) corresponds to the carbon leakage.

introduction of *Export Rebates* (ER) in the EU CBAM design. ER are export subsidies calibrated to neutralize the domestic carbon price for the EU exports of CBAM goods to non-regulated markets (see Section 2.3 for a detailed description of the different policy instruments).

The extensions of the EU CBAM heterogeneously alter the attractiveness of the climate policy in the EU and abroad (see Section B.1 in the Supplementary Materials for a detailed analysis). Wide, deep and comprehensive EU CBAMs are more effective in reducing carbon leakage and thereby reducing the income losses from implementing climate policies. These CBAM extensions also increase the burden shifting effect, with non-EU countries suffering higher income losses due to the CBAM. Export rebates come at a higher cost for the EU, but they are also effective in reducing carbon leakage, reducing the distortion on international markets and limiting the negative shock on non-EU countries (see Figure B.2 in the Supplementary Materials).

Because of these qualitative differences, the coalition building potential of the EU CBAM strongly varies under alternative implementation options (Table 1). Both the *deep* and the *wide* extensions of the EU CBAM extend the main coalition with an additional member, Brazil. Still, the *deep* CBAM yields more emission reduction (871 MtCO₂) than the *wide* CBAM (803 MtCO₂), because it performs relatively better at limiting carbon leakage (see Table B. 1 in the Supplementary Materials). The combination of the *deep* and *wide* extensions of the CBAM - i.e. the *comprehensive* option - results in the broadest coalition. Such a comprehensive CBAM would motivate the adoption of carbon pricing in 9 of the 15 regions covered in our analysis, notably including the US. Still, the comprehensive CBAM remains far from inducing full commitment: major emitters such as Russia, China and India would still remain outside of the coalition. In contrast, the introduction of export rebates shrinks the coalition-building potential of the EU CBAM: in our

model, export rebates cannibalise a large share of the climate policies' fiscal revenue, while only partially addressing export leakage (see Figure B.3 in the Supplementary Materials). This makes the adoption of the climate policy less attractive, and no other country joins the coalition in this case (Figure C.6 in the Supplementary Materials highlights that Japan and Taiwan are successively willing to join the coalition, but the resulting coalition is not stable).

CBAM implementation	Countries in the coalition	Overall emission reduction (MtCO₂)
EU CBAM	EU, CAN, KOR, JPN, TWN	691
wide CBAM	EU, BRA, CAN, JPN, KOR, TWN	803
deep CBAM	EU, BRA, CAN, JPN, KOR, TWN	871
comprehensive CBAM	EU, BRA, CAN, IDN, JPN, KOR, MEX, TWN, USA	1 259
CBAM with ER(*)	EU (JPN, TWN)	470

Table 1: **Overview of climate coalitions triggered by different EU CBAM implementation options.** The asterisk (*) highlights unstable outcomes of the coalition-building game. In this case, stable sub-coalitions and the resulting emission effects are reported. The countries in parentheses correspond to the maximum coalition size reached within the game.

3.2.2 Carbon price level

The magnitude of emission reduction achievable through carbon pricing is directly related to the emission price level. As the emission price increases, the distortion of the economy intensifies, thereby increasing the economic cost of the policy intervention (see the detailed analysis in the Supplementary Materials, Section B.2, and in particular Figure B.4). In consequence, the carbon price level plays a direct role in the attractiveness of climate policies for non-EU countries. Figure 5 highlights the trade-off between the intensive (carbon pricing stringency) and the extensive margin (coalition size) of the climate coalition: lower carbon prices favour the adoption of carbon pricing in a broader coalition of countries, while higher carbon prices increase the level of mitigation achieved in committed countries (Nordhaus, 2021; Farrokhi and Lashkaripour, 2025; Bourany, 2025). For instance, with a minimal carbon price of 10 USD/tCO₂, all countries but Russia (and the ROW aggregate, by design) form a stable climate coalition, achieving 770 MtCO₂ of overall emission reduction. India defects from the climate coalition at 20 USD/tCO₂, but the global emission reduction then reaches its maximum 1150 MtCO₂. Above 20 USD/tCO₂, China also defects from the coalition, which shrinks the mitigation level reached by the coalition.

The mitigation level of the coalition then reaches two other local maxima, both of which bring similar emission reduction levels as the largest coalition, with much smaller coalitions. A 55 USD/tCO₂ carbon price yields a club with 10 members (excluding China, India, Mexico, Russia and the ROW) and abates 758 Mt of CO₂ emissions. At 130 USD/tCO₂, a 4-member coalition (EU, Japan, Korea and Taiwan) reaches again 772 Mt of CO₂ emission reduction.

3.3 Sensitivity analysis

In what follows, we evaluate the sensitivity of the coalition building potential of the EU CBAM to key model parameters. In Section 3.3.1, we explore the influence of the substitutability of traded products. Section 3.3.2 exploits an alternative formulation of the model that uses Constant Elasticities of Substitution (CES) instead of Cobb-Douglas production functions to evaluate how different assumptions on the substitutability between intermediate inputs, primary factors and the natural resource input affect the coalition building potential of the EU CBAM.

3.3.1 Trade substitutability

In response to the EU CBAM, affected firms and consumers can respond by reducing their reliance on the most affected trade partners (Pothén and Hübler, 2018). In the trade model introduced in 2.1.2, the capability of economic agents to find alternative trade partners is controlled via sector-specific trade elasticities (see equation III). These trade elasticities are based on empirical estimates of trade responses to tariff shocks (Fontagné et al., 2022), whose exact values are uncertain. We evaluate here the sensitivity of the coalition formation game to these trade elasticities, by reassessing the main scenario of section 3.1 with trade elasticities scaled up and down by 30%.

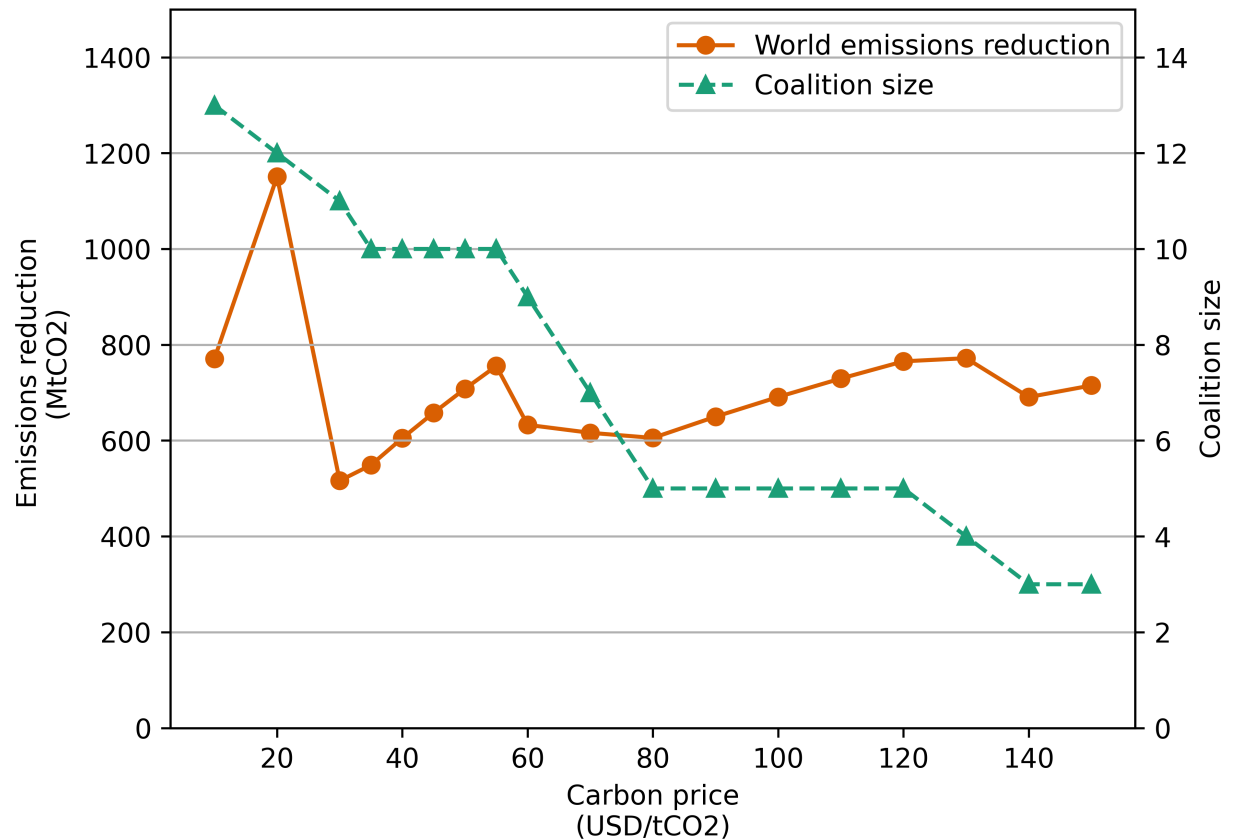


Figure 5: **Sensitivity of the coalition-building potential of the EU CBAM to the carbon price level.** The orange line indicates the level of industrial emission reduction achieved by a coalition of countries applying an ETS and a CBAM mimicking the EU climate policies, under different carbon price levels (x-axis). The green, dashed line indicates the number of countries willing to apply the climate policy under alternative carbon price levels. For settings yielding unstable coalitions, the results of the largest stable sub-coalition are used. Note that we suppose that the EU always commits to its climate policies and that the rest-of-the-world (ROW) region never joins the coalition: the maximum coalition size is 14.

The trade elasticities play a key role in ensuring the efficiency of the CBAM: high trade elasticities allow non-abiding countries to largely reshuffle their trade relations and, in turn, undermine the effect of the CBAM (see Section B.3 in the Supplementary Materials for a detailed analysis of the underlying mechanisms). High elasticities thus reduce the attractiveness of the climate coalition to non-EU countries. Figure 6 shows that increasing the trade elasticities by 30% shrinks the size of the potential coalition to the EU and Japan (green dashed line). Conversely, under the assumption that the trade elasticities are 30% lower than in our baseline, the climate coalition would include eight countries and reduce global emissions by 840 MtCO₂ (orange line). Importantly, the trade elasticities only play an important role on the effectiveness of the climate policy through the change in coalition size. For a given coalition size, a change of 10 percentage points in the trade elasticity change has a negligible effect on the volume of emission reduction achieved (see the orange line from -10% to 0 change from the baseline in Figure 6, or Figure B.5 in the Supplementary Materials for the EU applying the climate policy alone).

3.3.2 Input substitutability

Another key response mechanism to carbon pricing is the change in the demand for emission-intensive products (Hübler et al., 2024). The main specifications of our trade model rely on Cobb-Douglas production functions. In this section, we relax this assumption by exploiting an alternative formulation of the model with Constant Elasticity of Substitution (CES). Under these specifications (see Section A.2 in the Supplementary Materials for the complete description of the model), we specify three levels of substitution. First, the intermediate and final consumers can substitute between

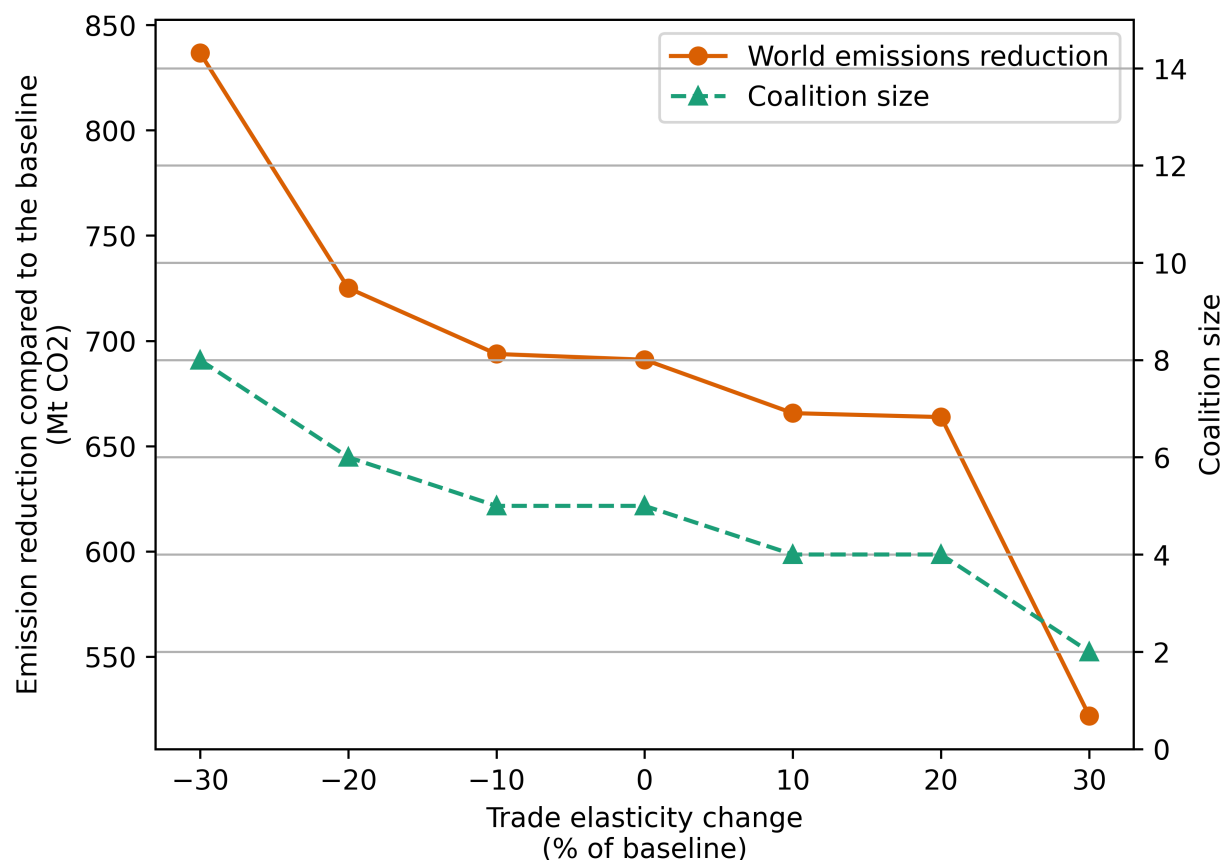


Figure 6: **Effect of a uniform change in trade elasticities on the outcome of the coalition formation in response to the EU CBAM.** The dotted green line shows, for a given increase or decrease in the trade elasticities (x-axis), the size of the coalition formed in reaction to the implementation of the EU CBAM. The orange line shows the associated volume of overall emission reduction. Note that all the coalitions shown here are stable.

non-primary inputs under an elasticity of substitution η . Second, the producers can substitute between their bundle of primary factors and their bundle of intermediate inputs with a substitution elasticity ρ . Third, within the bundle of primary inputs, the fossil fuel extraction sector can substitute between the general labour primary input and the natural fossil fuel resource with an elasticity of substitution ν .

The key results and mechanisms of the main scenario are mostly preserved in the central CES specifications (see Figure B.6 in the Supplementary Materials), with the exception of Canada, which does not join the climate coalition under the EU CBAM scenario. Figure 7 shows the sensitivity of the coalition formation to a range of possible values for the three CES parameters: our finding that the EU CBAM triggers the formation of a climate coalition holds across the full range for all substitution parameters. All three parameters play an important role in the volume of emission reduction achieved through the climate policy (orange lines): increasing the elasticities of substitution generally makes the climate policy more effective (see Section B.4 in the Supplementary Materials for a detailed analysis of the mechanisms). Still, these parameters have relatively little effect on the size of the coalition triggered by the EU CBAM: under all CES specifications, the same core group of 4 countries (the EU, Japan, Korea and Taiwan) remain in the coalition.

Both the substitutability parameters between primary and intermediate inputs (ρ , panel) and between the labour and natural resource primary inputs (ν) have a marginal effect on the resulting coalitions. A higher substitution rate between primary and intermediate inputs allows substituting emissions-intensive inputs with capital and labour, which makes emission reduction cheaper. The elasticity of substitution between the natural resources and the labour input (ν , right panel) alters the ability of fuel producers to adjust their production output to a change in fuel prices (Caron and Fally, 2022): a higher elasticity of substitution between primary factors decreases the fuel leakage effect and increases the

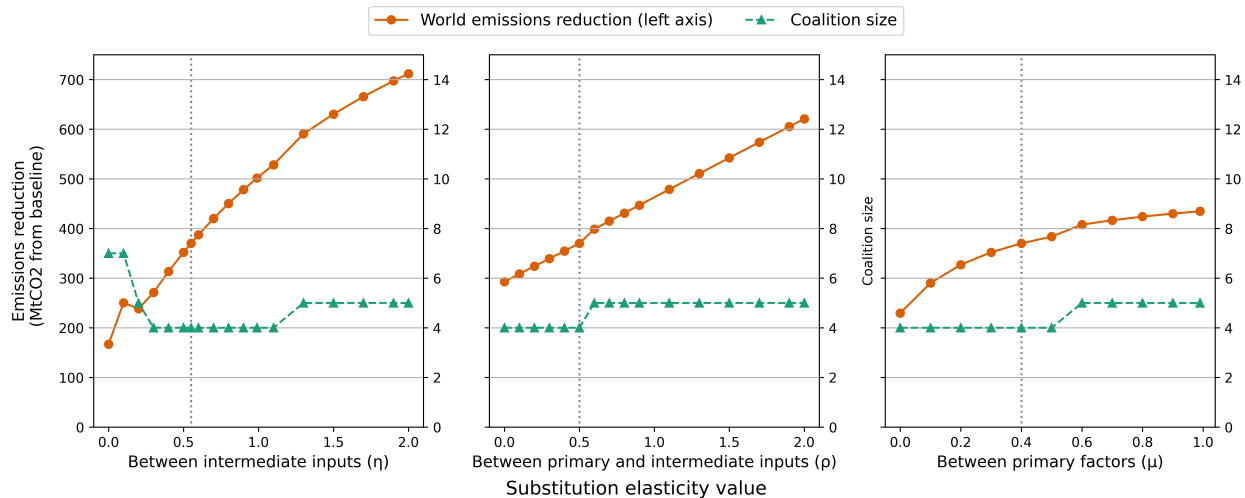


Figure 7: Coalition and emission reduction potential of the EU CBAM under different CES production function specifications of the model. The three panels show the changes in coalition size (dotted green lines) and overall emission reduction (orange lines) resulting from the coalition-building game when varying the three elasticities of substitution introduced in the CES specification of the trade model (see Section A.2 in the Supplementary Materials). The influence of each elasticity parameter is assessed separately, with the two other elasticity parameters set to their reference level (indicated by a grey, dotted line). Note that all the coalitions shown here are stable coalitions.

income losses for the fuel exporters. In both cases, a coalition of four countries is always formed (EU, Japan, Korea and Taiwan), and Canada additionally joins the coalition if the respective elasticity is above 0.5.¹⁴

The elasticity of substitution between intermediate inputs (η , left panel) affects how strongly the demand for final and intermediate emission-intensive products is changed in response to the climate policy. When the elasticity of substitution is close to 0 (i.e., close to Leontief production functions), the demand for fossil fuels and emission-intensive products is mostly unaffected, which leads to extremely high leakage rates and strongly inhibits the mitigation potential of the climate policy (orange line). When the elasticity of substitution is, by contrast, high, producers and consumers can more easily substitute away from fossil fuels and emission-intensive inputs, which increases the level of emission reduction. However, a higher elasticity of substitution between intermediate inputs also facilitates the adjustment of the production structure in other countries, which makes the climate policy costlier for the coalition members (see Section B.4 and Figure B.7 in the Supplementary Materials). The interaction between these antagonistic flexibility mechanisms results in an ambiguous effect on the coalition size. At a very low substitution elasticity, Brazil, Canada and the US complement the coalition formed by the EU, Korea, Japan and Taiwan, but these three countries leave the coalition at elasticities of substitution above 0.3. When intermediate inputs become complements rather than substitutes ($\eta > 1$), Canada joins the coalition again.

4 Discussion

In this section, we discuss the key assumptions underlying the trade model (4.1), the underlying calibration (4.2), the coalition-building game (4.3) and we put into perspective the main mechanisms underpinning the formation of climate coalitions (4.4).

4.1 Trade model

Our general equilibrium model largely builds on Caliendo and Parro (2015). In comparison with CGE models usually applied for studying the effects of the EU CBAM (e.g., Perdana and Vielle, 2023; Böhringer et al., 2012), our modelling

¹⁴The elasticity of substitution between primary factors controls how much the fuel income losses are channelled to the general labour input. As discussed in Footnote 13, Canada relatively benefits from implementing the climate policy when income losses are high enough to make the low wages a relative comparative advantage for other sectors for Canada. This requires a sufficiently high elasticity of substitution ν .

framework abstracts from many potentially important mechanisms (Bekkers et al., 2023). For instance, we aggregate all countries' final use into a single representative agent, thereby not evaluating the heterogeneous effects on households and governments, and we model a static counterfactual equilibrium, leaving technological change and investment trajectories out of the model. Despite these simplifications, the results we obtain for the abatement levels, carbon leakage and income effects are well within the range of typical ex-ante estimates (Böhringer et al., 2022). In addition, our sensitivity analysis to alternative production functions (see Section 3.3.2) highlights that the technical specifications of the model seem to play a secondary role for the key result of the paper, i.e., on the ability of the EU CBAM to trigger the formation of a climate coalition.

In turn, these simplifications increase the traceability of our analysis, reduce the calibration and computation effort and permit the modelling of a range of policy options largely overlooked in the existing literature. In addition, a growing literature is extending the original Caliendo and Parro (2015) model, which can be used in further research for enriching our modelling approach (e.g. Duan et al., 2021; Caron and Fally, 2022; Mahlkow and Wanner, 2023; Sogalla, 2023).

4.2 Baseline calibration and data limitations

Our analysis builds on MRIO data from 2014 (Timmer et al., 2016). In the meantime, the world economy underwent major changes, including a global pandemic and trade sanctions between major economies (e.g. between the United States and China or between the EU and Russia). While the availability of MRIO data for the most recent years at high sectoral and regional detail is limited, some more recent MRIO tables are already available (e.g., Aguiar et al., 2022) and can readily be exploited in future work using the methodological framework introduced here.

More generally, the sectoral aggregation of MRIO tables is a challenge for analysing the effects of the EU CBAM. In our model, we use emission data at the process level (Gütschow et al., 2021b,a) to model the EU CBAM below the MRIO sector level. The availability of process-level emission data is, however, limited to countries listed in the Annex I of the United Nations Framework Convention for Climate Change (UNFCCC), which notably excludes China, India and Indonesia (Gütschow et al., 2021b). An avenue to overcome such data limitations is to use average values for these countries, but this approach overlooks potentially important country-specificities. Instead, we use the mapping procedure described in Beaufilet et al. (2023a) and used in Beaufilet et al. (2023b). It combines process-level UNFCCC emission factors from Gütschow et al. (2021b), sector-country production data from WIOD (Timmer et al., 2016) and aggregated UNFCCC emission data (Gütschow et al., 2021a) to derive process-level emission data for all countries, which more accurately capture the countries' characteristics.

Practically, such emission data allow isolating product-specific emissions and estimating the carbon intensity of the products covered by the CBAM more precisely (Beaufilet et al., 2023b). However, process-level emission intensities (e.g. steel production emissions) are still aggregated at the sector level (e.g. basic metals) when applying the taxes and tariffs: the specific products targeted by the EU CBAM are diluted into the larger MRIO sectors, which might cause us to misfeature some product-specific characteristics. Additionally, this approach only isolates the direct emissions at the sub-sector level. Indirect emissions are still estimated at the sector level, which might lead to an overestimation of the coverage of the CBAM - and thus the efficiency of this policy instrument. Again, the use of more disaggregated MRIO data can partially overcome these limitations.

4.3 Coalition formation

The coalition formation game introduced in Section 2.2 builds on four key assumptions regarding the rationality of the countries, namely myopic decisions, non-cooperativeness, binary moves and income-maximization.

Myopic decisions In our coalition formation game, the countries do not form beliefs on the future moves of other countries. As a consequence, best-response moves in early stages of the game might lead to comparatively worse outcomes for the coalition countries in the final stage of the game (see the case of Canada in Figure 3). In principle, this violates the *profitability* criterion of Carraro and Siniscalco (1993), which states that membership of a stable coalition should constitute an absolute welfare improvement for all coalition members.

In the related literature, the profitability of the resulting coalition is either overlooked (Böhringer et al., 2016) or ensured by integrating climate benefits into the coalition formation game (Bourany, 2025; Farrokhi and Lashkaripour, 2025; Nordhaus, 2015, 2021). However, the benefits of climate mitigation are notoriously difficult to quantify (Nordhaus, 2019; Auffhammer, 2018). In our analysis, we purposely exclude the gains from mitigation: the countries only join the coalition if it brings them direct economic gains compared to the status quo. By design, this feature leads to underestimating the attractiveness of the climate coalition and arguably makes our results on the coalition-building potential of the EU CBAM conservative.

Scenario	Sufficient Social cost of carbon (USD/tCO ₂)
EU ETS	28.8
EU CBAM	1.1
Wide CBAM	1.0
Deep CBAM	1.2
Comprehensive CBAM	4.2
CBAM with Export Rebates	13.1

Table 2: **Sufficient Social cost of carbon value ensuring the profitability of the coalition under alternative EU CBAM designs.** We define the Sufficient Social Cost of Carbon as the National Social Cost of Carbon ensuring that all the countries in the coalition benefit from being part of the coalition, compared to the baseline without climate policy. The values are estimated by dividing the real income losses in each country by the global level of emission reduction (see Table D. 7 for the estimates at the country level), and we report here the maximum value among coalition countries. We take the coalitions of Table 1 as given: we omit the potential extension of the climate coalition once unilateral climate damages are internalised.

Keeping the benefits from climate mitigation out of the model makes the profitability criterion unlikely to be met in general: the climate policies we introduce in the trade model are by design distortive, and thus globally welfare-decreasing. Still, Table 2 evaluates the minimum unilateral social cost of carbon that would ensure all members of the stable coalitions to meet the profitability criterion of Carraro and Siniscalco (1993). In our main scenario, a unilateral social cost of carbon of 1.1 USD/tCO₂ is sufficient to ensure the profitability of the policy to all members of the coalition. This value is well below recent estimates of the Social Cost of Carbon (Rennert et al., 2022; Moore et al., 2024; Bilal and Känzig, 2026),¹⁵ which makes a strong case for the general validity of our results.

Non-cooperative moves We assume that countries make individual decisions and do not coordinate with other countries to join or leave the coalition. This implies that the result of our coalition game might not be coalition-proof: even if countries might not want to defect (or join the coalition) individually, they could potentially change their decisions conditionally on other countries' decisions. In the related literature, Nordhaus (2015, 2021) and Bourany (2025) provide sub-coalition-proof equilibria, following the convex properties of their model specifications (quadratic climate mitigation benefits and reduced-form trade sanctions). As in Böhringer et al. (2012) and Farrokhi and Lashkaripour (2025), the richness of our quantitative trade model forbids a mathematical proof of the coalition-stability of the resulting coalition, and the many possible sub-coalitions make the property burdensome to evaluate in practice. Instead, Böhringer et al. (2012) and Farrokhi and Lashkaripour (2025) postulate prohibitive reputational costs for coalition members to deviate from the resulting equilibrium (they also use these hypothetical costs to forbid defections in the coalition formation process and to avoid explicitly evaluating the internal stability of the resulting coalitions). Here, we simply acknowledge that allowing joint moves could potentially change the outcome of the coalition building game.

Binary choice In our coalition formation game, countries face a binary choice between perfectly mirroring the EU climate policy or doing nothing. In reality, policy responses to the EU CBAM can take a broad range of formats (Otto, 2025), which could include retaliation (Böhringer et al., 2012) or the implementation of a carbon market with a smaller scope or price level. In principle, our modelling framework can accommodate a variety of policy options. However, the inclusion of a broader policy response space yields additional numerical complexity and interpretation challenges. For this reason, the binary choice setting we use is common to all the related literature (Nordhaus, 2015, 2021; Farrokhi and Lashkaripour, 2025; Bourany, 2025) (at the exception of Böhringer et al. (2012), which includes a retaliation option). While out of the scope of this paper, evaluating a broader range of policy responses is an important avenue for future research.

Rationality We assume that all countries (except for the EU and the ROW region) make income-maximizing decisions and ignore all the other implications of their climate policy. In reality, a broad range of factors might influence a country's decision of implementing climate policies such as expected climate benefits, geopolitical implications or political dynamics (Sabyrbekov and Overland, 2024). Our modelling framework can be extended to embed additional parameters susceptible to changing the criteria for countries to join a climate coalition: the countries' decision-making

¹⁵Note that the Social Cost of Carbon is usually assessed at the global level, i.e., taking into account the aggregated damages in all countries. Instead, the values of Tables 2 and D. 7 refer to sufficient domestic costs of carbon. Beyond climate damages (see, e.g. Ricke et al., 2018), domestic Social Cost of Carbon can also entail local co-benefits of emission reduction, e.g. on health or energy security (Karlsson et al., 2020; Beaufls et al., 2025).

function W in the coalition formation game (Equation 16) can follow any functional form, e.g. including climate change damages, weights based on countries' geopolitical proximity (Bailey et al., 2017) or behavioural assumptions.

4.4 Mechanism analysis

Because of the absence of gains from climate mitigation here, the fundamental mechanism of the coalition formation in our model is the competition for a CBAM rent, similar to a beggar-thy-neighbour mechanism (Zhong and Pei, 2022). The countries imposing the CBAM extract a fiscal revenue from their imports, which compensates for the cost of applying a domestic climate policy (see Figures C.2 and C.4 in the Supplementary Materials). First, when a trade partner joins the climate coalition, its industries exporting to the countries within the coalition pay the same carbon price than before joining the coalition, but the associated fiscal revenue now accrue to the country itself - instead of to the coalition members (Beaufils et al., 2023b). Second, joining the coalition allows countries to charge a tariff on their imports, which can result in terms-of-trade gains (Farrokhi and Lashkaripour, 2025).

The first channel explicitly depends on how much a country exports to the existing coalition, while the second relies on how much it imports from outside the coalition. In the analysis, we show that Canada, Japan, Korea and Taiwan join a CBAM-based climate coalition under most CBAM designs (Section 3.2) and model specification (Section 3.3). Still, these countries are not the closest trade partners of the EU. This highlights the domination of the second channel, i.e., the terms-of-trade gains, in the formation of the coalition. Indeed, additional simulations show that Canada, Japan, Korea and Taiwan would form a CBAM-based coalition even in the absence of the EU (Figure C.7, Supplementary Materials).

In that regard, the role of the EU for triggering the adoption of climate policies is mostly indirect: CBAMs are complex regulatory instruments, whose implementability has long been disputed (Cosbey et al., 2019). Being the first of its kind, the EU CBAM creates a precedent and a standard that can be replicated elsewhere. This echoes the Brussels' effect concept: due to the EU's central position in international supply chains, the policies adopted in Brussels diffuse outside the EU's territory (Bradford, 2020). The *de jure* Brussels' effect implies the adoption of policies mirroring the EU regulations in non-EU countries and the *de facto* Brussels' effect postulates multinational firms to abide to the EU regulations globally. Our findings support and quantify the hypothesis that the EU CBAM is susceptible to triggering a *de jure* Brussels' effect, as proposed in Bernat and Spera (2024) and Otto (2025). A similar diffusion of climate policies through learning effects has also been identified for carbon pricing by Linsenmeier et al. (2023).

5 Conclusion

This paper introduces a modelling framework to evaluate the potential of the EU CBAM to trigger the formation of a climate coalition. In comparison with the existing literature, we use a highly resolved trade model, which allows a rich representation of the EU CBAM (process emissions, precise scope definition). Our key results show that, under its current implementation, the EU CBAM not only limits the domestic cost of the EU climate policy but also motivates the adoption of climate policies in other countries.

First, our numerical analysis highlights that, even under its current design, the EU CBAM succeeds in reducing carbon leakage in the EU (15% of leakage with the EU CBAM, compared to 40% for the ETS without an anti-leakage instrument). This simultaneously reduces the cost of the EU climate policy while increasing its effectiveness in terms of global emission reduction. These results align with the existing literature on the EU CBAM (Böhringer et al., 2022; Zhong and Pei, 2024), and our model reproduces the characteristic features of the EU CBAM, such as the burden-shifting effect captured in Figure 1.

Second, we show that the EU CBAM will have knock-on effects on climate policies in the rest of the world. In its current form and without expected gains from climate mitigation, the EU CBAM can ground a stable climate coalition consisting of the EU as well as Canada, Korea, Japan and Taiwan. Our results suggest that, by inducing the adoption of carbon pricing in other countries, the strategic implications of the EU CBAM amplify the emission reduction potential of the EU climate policy. In our main scenario, accounting for the policy response of the EU trade partners augments the abatement potential of the EU climate policy by 73% and quadruples the effect of the CBAM on global emissions. This insight concurs with a growing qualitative and quantitative literature highlighting the potential for the EU to diffuse its climate policies along supply chains (Beaufils et al., 2023b; Böhringer et al., 2016; Bernat and Spera, 2024). This mechanism also seems to align with ongoing political developments, as multiple countries have already declared their willingness to adopt climate policies in response to the EU CBAM (Otto, 2025).

While the general coalition-building potential of CBAMs and related carbon tariffs was already discussed in the literature (Lessmann et al., 2015; Nordhaus, 2015, 2021; Farrokhi and Lashkaripour, 2025), we are here able to test the sensitivity of this potential to a broad range of CBAM designs and modelling assumptions. We find the core coalition

of the EU, Korea, Japan and Taiwan to be stable under a very broad range of carbon prices, modelling assumptions and CBAM scopes, while the commitment of Canada is sensible to assumptions on input substitutability. Still, our sensitivity analysis bring nuanced results on the role of different parameters for the formation of a CBAM-based climate coalition: the level of trade elasticities plays a minor role for the unilateral effectiveness of the CBAM but largely controls the size of the resulting coalition. Instead, alternative production function specifications strongly influence the unilateral effectiveness of the climate policy but only marginally influence the coalition size. In accordance with the literature, we find the carbon price level to moderate a trade-off between the external margin (the size of the coalition) and the internal margin (the level of emission reduction per country) (Farrokhi and Lashkaripour, 2025; Bourany, 2025). Here, the perspective of forming an almost-universal coalition (only excluding Russia and India) suggests that lower carbon prices can yield higher global emission reductions.

Finally, we find the exact design of the EU CBAM to play a crucial role for the coalition size: if the EU were to implement a comprehensive CBAM (i.e., covering all ETS sectors and all upstream emissions), it would trigger the formation of a coalition which would include Brazil, Indonesia and the US, but exclude Russia, India and China. Conversely, we find that fully rebating the carbon price on exports is so costly that it renders the coalition unattractive for other countries. This insight provides a novel argument against the potential inclusion of export rebates in the EU CBAM, along with legal and efficiency concerns (Jakob and Mehling, 2025; Leonelli, 2022).

For policymakers, our analysis shows that, in addition to partially protecting the EU against carbon leakage, the EU CBAM has an important potential to diffuse climate policies beyond the EU, thereby contributing to overcome the challenges of international climate coordination. The sensitivity of our results to different CBAM implementation options calls for more research evaluating the key design features maximizing such coalition potential.

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Supplementary materials

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A Model information

A.1 Implementation

This section entails practical notes for running the model.

Calibration in the absence of trade deficits The trade model assumes constant trade deficits in nominal terms (Equation V). Fixing non-null trade deficits would force the model into unconditional transfers from the countries with a trade deficit to countries with a trade surplus. To minimise the influence of the initial deficit values on the final equilibrium, we first neutralise the trade balances before applying the policy shocks. This *neutralised* equilibrium is used as the baseline for running the model.

World revenue normalisation In addition to a constant trade deficit, we follow Caliendo and Parro (2015) and normalise world GDP to remain constant in the counterfactual equilibrium:

$$\sum_s \widehat{v}_s v_s = \sum_s v_s. \quad (\text{A. 1})$$

Evaluation of the variables of interest The net fiscal revenue from the input taxes, tariffs and subsidies in country s , $\kappa'_\tau{}^s$, derives from the sectoral expenditures *including output tariffs and subsidies* on each product j from country r and is expressed as:

$$\kappa'_\tau{}^s = \sum_{i,r} (\widehat{\tau}_{ir}^s \tau_{ir}^s - 1) \frac{\widehat{\pi}_{ir}^s \pi_{ir}^s}{\widehat{\tau}_{ir}^s \tau_{ir}^s} x_i^{s'}. \quad (\text{A. 2})$$

Conversely, the net revenue of output taxes and subsidies ($\kappa'_\eta{}^s$) is calculated from the sum of exports of all products j to each country r :

$$\kappa'_\eta{}^s = \sum_{j,r} (\widehat{\zeta}_{js}^r \zeta_{js}^r - 1) \frac{\widehat{\pi}_{js}^r \pi_{js}^r}{\widehat{\tau}_{js}^r \tau_{js}^r \widehat{\zeta}_{js}^r \zeta_{js}^r} x_j^{r'}. \quad (\text{A. 3})$$

The emissions caused by burning fuel f in sector i of country s , $E_f'^{is}$, derive from fuel input share in monetary terms (γ_f^{is}), the gross production of the sector and the nominal fuel intensity (e_f^s . see 12):

$$E_f'^{is} = \frac{e_f^s}{\widehat{p}_f^s} \gamma_f^{js} \sum_r \frac{\widehat{\pi}_{js}^r \pi_{js}^r}{\widehat{\tau}_{js}^r \tau_{js}^r \widehat{\zeta}_{js}^r \zeta_{js}^r} x_j^{r'}. \quad (\text{A. 4})$$

The process emissions from the sector i in country s , $E_p'^{is}$ similarly derive from the gross production of the corresponding sector and the process-specific emission intensity (e_{is} . see 15):

$$E_p'^{is} = \frac{e_{is}}{\widehat{c}_{is}} \sum_r \frac{\widehat{\pi}_{is}^r \pi_{is}^r}{\widehat{\tau}_{is}^r \tau_{is}^r \widehat{\zeta}_{is}^r \zeta_{is}^r} x_i^{r'}. \quad (\text{A. 5})$$

A.2 CES Model extension

In this section, we extend the core quantitative model introduced in 2.1.2 with a two-tiered Constant Elasticity of Substitution (CES) production function. At the top level, we make the bundle of primary inputs for producing j in country s , v_{js} substitutable with the bundle of intermediate inputs X^{js} , with a constant elasticity of substitution ρ . At the lower level, inputs sourced by final and intermediate users from different sectors i are substitutable with a constant elasticity of substitution η . Under these conditions, the price change of the input bundle (see Equation I) becomes:

$$\hat{c}_{js} = \left(\gamma^{js} (\hat{v}^{js})^{1-\rho} + \gamma_M^{js} (\hat{p}_M^{js})^{1-\rho} \right)^{\frac{1}{1-\rho}}, \quad (\text{S. I})$$

where γ_M^{js} is the sum of the technical coefficients of all intermediate inputs:

$$\gamma_M^{js} = \sum_i \gamma_i^{js}. \quad (\text{A. 6})$$

The price index change for the intermediate input bundle, $\hat{p}_M^{js}$ follows the price change of each individual input r , $\hat{p}_r^s$, weighted by its respective share in the input bundle for producing j in country s , noted β_r^{js} and geometrically weighted by the elasticity of substitution between intermediate inputs, η :

$$\hat{p}_M^{js} = \left(\sum_r \beta_r^{js} (\hat{p}_r^s)^{1-\eta} \right)^{\frac{1}{1-\eta}}. \quad (\text{S. II})$$

As in the original formulation of the model, the price change for input i in country s is derived from the production cost changes in origin countries ($\hat{c}_{ir}^s$), the input tariffs and subsidy changes ($\hat{\tau}_{ir}^s$), output tariff and subsidy changes ($\hat{\varsigma}_{ir}^s$) and sector-specific trade elasticities θ_i :

$$\hat{p}_i^s = \left(\sum_r \pi_{ir}^s \left(\hat{\tau}_{ir}^s \hat{\varsigma}_{ir}^s \hat{c}_{ir}^s \right)^{-\theta_i} \right)^{-\frac{1}{\theta_i}}. \quad (\text{S. III})$$

The nominal cost shares for the primary input bundle ($\hat{\gamma}^{js}$), for the intermediate inputs bundle ($\hat{\gamma}_M^{js}$) and for the share of individual products in the intermediate bundle ($\hat{\beta}_r^{js}$) depends on relative price of that input compared to the bundle price level:

$$\begin{cases} \hat{\gamma}^{js} &= \left(\frac{\hat{v}_{js}}{\hat{c}_{js}} \right)^{1-\rho}; \\ \hat{\gamma}_M^{js} &= \left(\frac{\hat{p}_M^{js}}{\hat{c}_{js}} \right)^{1-\rho}; \\ \hat{\beta}_r^{js} &= \left(\frac{\hat{p}_r^s}{\hat{p}_M^{js}} \right)^{1-\eta}. \end{cases} \quad (\text{S. IV})$$

As in the main specifications, the adjustment of the trade shares ($\hat{\pi}_{ir}^s$) depends on the cost change in exporting country r (including tariffs and subsidies) relative to the price index change in importing country s :

$$\hat{\pi}_{ir}^s = \left(\frac{\hat{\tau}_{ir}^s \hat{\varsigma}_{ir}^s \hat{c}_{ir}^s}{\hat{p}_i^s} \right)^{-\theta_i}. \quad (\text{S. V})$$

The counterfactual expenditure on product i in country s , $x_i^{s'}$, is adjusted to account for the change of nominal use shares for both individual intermediate inputs ($\hat{\beta}_r^{js}$) and the intermediate input bundle ($\hat{\gamma}_M^{js}$):

$$x_i^{s'} = \sum_j \gamma_M^{js} \hat{\gamma}_M^{js} \beta_r^{js} \hat{\beta}_r^{js} \sum_r \frac{\hat{\pi}_{js}^r \pi_{js}^r}{\hat{\tau}_{js}^r \tau_{js}^r \hat{\varsigma}_{js}^r \varsigma_{js}^r} x_j^{r'} + \hat{\alpha}_i^s \alpha_i^s y^{s'}, \quad (\text{S. VI})$$

where α_i^s is country s 's final expenditure share on goods from sector i and $y^{s'}$ is country s 's total counterfactual consumption and $\hat{\alpha}_i^s$ the nominal change in the consumption basket.

The price index for the final consumption basket (and for evaluating the real welfare effect, equation 9) in country s , $\hat{p}^s$, is now defined as:

$$\hat{p}^s = \left(\sum_i \alpha_i^s [\hat{p}_i^s]^{1-\eta} \right)^{\frac{1}{1-\eta}}. \quad (\text{S. VII})$$

The final consumption share of the product i in the production basket of country s , $\hat{\alpha}_i^s$, is related to the relative price of that product, $\hat{p}_i^s$, compared to the overall price index $\hat{p}^s$:

$$\hat{\alpha}_i^s = \left(\frac{\hat{p}_i^s}{\hat{p}^s} \right)^{1-\eta}. \quad (\text{S. VIII})$$

As in the main specification, the counterfactual final consumption value in country s , y'^s , is the sum of the primary inputs revenues, the net fiscal cost and revenues of input and output tariffs and subsidies (Equations A. 2 and A. 3) and the (exogenous) trade deficit (d_s):

$$y'^s = \hat{v}_l^s v_l^s L^s + \sum_j \hat{v}_n^{js} v_n^{js} N^{js} + \sum_{i,r} (\hat{\tau}_{ir}^s \tau_{ir}^s - 1) \frac{\hat{\pi}_{ir}^s \pi_{ir}^s}{\hat{\tau}_{ir}^s \tau_{ir}^s} x_i^{s'} + \sum_{j,r} \left(\hat{\zeta}_{js}^r \zeta_{js}^r - 1 \right) \frac{\hat{\pi}_{js}^r \pi_{js}^r}{\hat{\tau}_{js}^r \tau_{js}^r \hat{\zeta}_{js}^r \zeta_{js}^r} x_j^{r'} + d_s. \quad (\text{S. IX})$$

The variation in the value share of labour in the sectoral value added to the sector i in country r , $\hat{\mu}_l^{ir}$ follows the cost of labour in the country, $\hat{v}_l^r$, relative to the cost of the value added bundle $\hat{v}_{ir}$, mediated by the elasticity of substitution between the two primary factors, ν :

$$\hat{\mu}_l^{ir} = \left(\frac{\hat{v}_l^r}{\hat{v}_{ir}} \right)^{1-\nu}. \quad (\text{S. X})$$

The value change of labour, $\hat{v}_l^{ir}$, derives from the demand of labour in the overall economy:

$$\hat{v}_l^s = \frac{1}{v_l^s L^s} \sum_j \hat{\gamma}^{js} \gamma^{js} \mu_l^{js} \hat{\mu}_l^{js} \sum_r \frac{\hat{\pi}_{js}^r \pi_{js}^r}{\hat{\tau}_{js}^r \tau_{js}^r \hat{\zeta}_{js}^r \zeta_{js}^r} x_j^{r'}. \quad (\text{S. XI})$$

Similarly, the share of natural resource $\hat{\gamma}_n^{js}$ in the sectoral value added equals the value change of the natural resource $\hat{v}_n^{js}$ divided by the price change of the value added bundle $\hat{v}^{js}$:

$$\hat{v}_n^{js} = \left(\frac{\hat{v}_n^{js}}{\hat{v}^{js}} \right)^{1-\nu}. \quad (\text{S. XII})$$

As for labour, the change in natural resource value, $\hat{v}_n^{js}$ derives from the overall demand in the economy:

$$\hat{v}_n^{js} = \frac{1}{v_n^{js} N^{js}} \gamma^{js} \mu_n^{js} \hat{\gamma}^{js} \mu_n^{js} \sum_r \frac{\hat{\pi}_{js}^r \pi_{js}^r}{\hat{\tau}_{js}^r \tau_{js}^r \hat{\zeta}_{js}^r \zeta_{js}^r} x_j^{r'}. \quad (\text{S. XIII})$$

Finally, the cost of the primary input bundle, $\hat{v}^{js}$ equals the combinations of the labour $\hat{v}_l^{js}$ and natural resources $\hat{v}_n^{js}$ inputs:

$$\hat{v}^{js} = \left(\mu_l^{js} (\hat{v}_l^{js})^{1-\nu} + \mu_n^{js} (\hat{v}_n^{js})^{1-\nu} \right)^{\frac{1}{1-\nu}}. \quad (\text{S. XIV})$$

The environmental extension of the model (Equations IX to XI) is not affected by the change in the production functions. The computation of embodied emissions (Section A.5) is also similar, with the exception that the expenditure shares in Equations A. 20 and A. 23 are to be evaluated with the counterfactual expenditure share $\gamma_i'^{js}$:

$$\gamma_i'^{js} = \gamma_i^{js} \hat{\gamma}^{js} \hat{\gamma}_M^{js}. \quad (\text{S. XV})$$

Calibration In the manuscript, we evaluate the sensitivity of the outcome of the climate policy when the EU implements it alone (Section B.4 in the Supplementary Materials) and when we use the coalition-building game of Section 2.2 (Section 3.3.2). In both cases, we evaluate the sensitivity of the outcome to a broad range of possible values for the three elasticity of substitution. For each parameter, we conduct this analysis by keeping the two other parameters at a constant, reference value.

We borrow the calibration of the reference elasticity of substitution between primary and intermediate from Atalay (2017) and Baqaee and Farhi (2024) ($\rho = 0.5$). Atalay (2017) and Baqaee and Farhi (2024) use different elasticity of substitution between sectors for the intermediate and final users. Here, our elasticity of substitution between intermediates, η , applies to both intermediate (Equation S. I) and final users (Equation S. VIII). We thus use the average of the final and intermediate elasticity of substitution from Atalay (2017) and Baqaee and Farhi (2024) ($\eta = 0.55$).

For the elasticity of substitution between the natural resource and labour primary factor, ν , we follow Caron and Fally (2022) and calibrate the reference elasticity of substitution to match a target fuel supply elasticity. We take this reference fuel supply elasticity from Larch and Wanner (2024), which average fuel supply elasticities for coal, oil and gas to 2. Using equation A.19 from Caron and Fally (2022) and the primary factor data at the world level from Aguiar et al. (2022), we take $\nu = 0.3$.

A.3 Trade model derivation

The core of our quantitative trade model is a Caliendo and Parro (2015)-type multi-country, multi-industry model with input-output linkages across sectors. Different from Caliendo and Parro (2015)'s Ricardian micro-foundation, we derive our model from an Armington (1969) assumption of nationally differentiated varieties, as this allows us to abstract from within-industry specialisation changes and their effects on produced quantities and industrial process emissions.

Consumers in n countries (indexed by s and r) have a two-tier utility function with Cobb-Douglas utility across m sectors (indexed by i and j) and CES utility across nationally differentiated varieties from all countries within sectors:

$$u^s = \prod_i \left(\left[\sum_r (\omega_{ir})^{\frac{1-\sigma_i}{\sigma_i}} (y_{ir}^s)^{\frac{\sigma_i-1}{\sigma_i}} \right]^{\frac{\sigma_i}{\sigma_i-1}} \right)^{\alpha_i^s}, \quad (\text{A. 7})$$

where ω_{ir} is a preference parameter, y_{ir}^s is the final consumption of country r 's sector i product in country s , σ_i denotes the elasticity of substitution between products from different origins, and α_i^s is country s 's expenditure share for sector j .

Production combines a value-added component with an intermediate composite in a Cobb-Douglas manner. The value-added part consists of only labour in most industries, but the primary fossil fuel sectors additionally contain a second primary factor, which is the fossil fuel endowment. The intermediate composite is a Cobb-Douglas aggregate of industry-level CES nests aggregating national varieties exactly as in the utility function:

$$q^{js} = A^{js} \left([L^{js}]^{\mu_l^{js}} [N^{js}]^{\mu_n^{js}} \right)^{\gamma^{js}} \prod_i \left(\left[\sum_r (\omega_{ir})^{\frac{1-\sigma_i}{\sigma_i}} (m_{ir}^{js})^{\frac{\sigma_i-1}{\sigma_i}} \right]^{\frac{\sigma_i}{\sigma_i-1}} \right)^{\gamma_i^{js}}, \quad (\text{A. 8})$$

where A^{js} denotes country s 's total factor productivity in sector j , L^{js} and N^{js} are the labour and natural resource inputs with respective cost shares μ_l^{js} and μ_n^{js} in value added, γ^{js} is the overall value added share in total input costs, m_{ir}^{js} is the intermediate quantity from sector i and country r used in country s 's sector j , and γ_i^{js} is input cost share of sector i in sector j in country s , with $\gamma^{js} + \sum_i \gamma_i^{js} = 1$. Unit costs are then given by:

$$c_{js} = \Upsilon^{js} \left([v_l^s]^{\mu_l^{js}} [v_n^s]^{\mu_n^{js}} \right)^{\gamma^{js}} \prod_i (p_i^s)^{\gamma_i^{js}}, \quad (\text{A. 9})$$

where $\Upsilon^{js} \equiv (A^{js})^{-1} (\gamma^{js})^{-\gamma^{js}} (\mu_l^{js})^{-\mu_l^{js}} (\mu_n^{js})^{-\mu_n^{js}} \prod_i (\gamma_i^{js})^{-\gamma_i^{js}}$, v_l^s and v_n^s denote the wage and natural resource prices, respectively, and p_i^s is the price index of sector i 's CES composite in country s , defined in equation A. 11 below.

International trade is subject to iceberg-type trade costs t_{ir}^s , as well as potentially import tariffs τ_{ir}^s and/or export taxes or subsidies ζ_{ir}^s . Bilateral trade shares follow a standard structural gravity equation:

$$\pi_{ir}^s = \left(\frac{t_{ir}^s \tau_{ir}^s \zeta_{ir}^s c_{ir}}{p_i^s} \right)^{-\theta_i}, \quad (\text{A. 10})$$

where $\theta_i = \sigma_i - 1$ denotes the trade elasticity, and the sectoral price index is given by

$$p_i^s = \left[\sum_r (\omega_{ir} t_{ir}^s \tau_{ir}^s \zeta_{ir}^s c_{ir})^{-\theta_i} \right]^{-\frac{1}{\theta_i}}. \quad (\text{A. 11})$$

A country's total expenditure on goods from a specific sector combines its producers' intermediate use of the products and its' consumers' final demand:

$$x_i^s = \sum_j \gamma_i^{js} \sum_r \frac{\pi_{jr}^s}{\tau_{js}^r \zeta_{js}^r} x_j^r + \alpha_i^s y^s, \quad (\text{A. 12})$$

where income combines factor income from labour and the natural resources with tax and tariff revenues, subtracting any subsidy payments:

$$y^s = v_l^s L^s + \sum_j v_n^{js} N^{js} + \sum_{i,r} (\tau_{ir}^s - 1) \frac{\pi_{ir}^s}{\tau_{ir}^s} x_i^s + \sum_{j,r} (\zeta_{js}^r - 1) \frac{\pi_{jr}^s}{\tau_{js}^r \zeta_{js}^r} x_j^r + d^s, \quad (\text{A. 13})$$

where d^s denotes an exogenous trade imbalance, with $\sum_r d^r = 0$.

Labour is assumed to be internationally immobile, but perfectly mobile across industries within a country. Natural resources are specific to their respective country and primary fossil fuel sector. Factor markets clear:

$$v_l^s L^s = \sum_j \mu_l^{js} \gamma^{js} \sum_r \frac{\pi_{js}^r}{\tau_{js}^r \zeta_{js}^r} x_j^r, \quad (\text{A. 14})$$

$$v_n^{js} N^{js} = \mu_n^{js} \gamma^{js} \sum_r \frac{\pi_{js}^r}{\tau_{js}^r \zeta_{js}^r} x_j^r. \quad (\text{A. 15})$$

We can then define an equilibrium of our trade model as follows, closely following Caliendo and Parro (2015):

Definition 1 For given labour endowments L^s , resource endowments N^{js} , technology and preference parameters ω_{jr} , σ_j , α_j^s , A^{js} , μ_l^{js} , μ_n^{js} , γ^{js} , and γ_i^{js} , trade costs t_{ir}^s , (trade) taxes and subsidies τ_{ir}^s and ζ_{ir}^s , and trade imbalances d_s , an equilibrium is a set of wages v_l^s , resource prices v_n^{js} , and composite price indices p_i^s that satisfy conditions (A. 9)–(A. 15).

In the main manuscript, we follow Dekle et al. (2007, 2008) and consider the equilibrium in relative changes. This has the advantage that the values of ω_{jr} , A^{js} , and t_{ir}^s need not be known or estimated. We obtain the equations in changes (Equations I - VIII, values denoted by a hat), by dividing the counterfactual values defined in Equations (A. 9) to (A. 15) by their baseline level.

A.4 Regulated fuel sector

Restricting the application of the fuel tax to a subset of intermediate sectors requires introducing a set of so-called *regulated fuel sectors*, denoted $\bar{f}$. The regulated fuel sectors fully supply the sectors paying the fuel input tax. In detail, the regulated fuel sectors hold the following properties:

1. The regulated fuel sectors $\bar{f}$ in country r supply exclusively the sectors covered by the carbon price $\bar{J}$:

$$\begin{cases} \forall i \in \bar{J} & \gamma_{\bar{f}}^{ir} = \gamma_f^{ir}; \\ \forall i \in \tilde{J} & \gamma_{\bar{f}}^{ir} = 0; \end{cases} \quad (\text{A. 16})$$

2. The non-regulated fuel sectors $\tilde{f}$ in country r supply the sectors not covered by the carbon price $\bar{J}$:

$$\begin{cases} \forall i \in \bar{J} & \gamma_{\tilde{f}}^{ir} = 0; \\ \forall i \in \tilde{J} & \gamma_{\tilde{f}}^{ir} = \gamma_f^{ir}; \end{cases} \quad (\text{A. 17})$$

3. The non-regulated fuel sector $\tilde{f}$ fully supply the regulated fuel sectors $\bar{f}$ and the regulated fuel sectors $\bar{f}$ does not supply the non-regulated fuel sectors $\tilde{f}$ ¹:

$$\begin{cases} \gamma_{\tilde{f}}^{\bar{f}r} = 1; \\ \gamma_{\bar{f}}^{\tilde{f}r} = 0; \end{cases} \quad (\text{A. 18})$$

4. Only the regulated sectors $\bar{f}$ in country r provide the domestic supply of regulated fuel:

$$\begin{cases} \pi_r^{\bar{f}r} = 1; \\ \forall s \neq r, \pi_r^{\bar{f}s} = 0. \end{cases} \quad (\text{A. 19})$$

Equations A. 16 to A. 19 define regulated fuel sectors $\bar{f}$ that are entirely supplied by the non-regulated fuel sectors $\tilde{f}$ and that supply all regulated sectors. By setting the fuel input tax on the intermediate sector only ($\tau_{\bar{f}r}^s = \tau_{f_r}^s$; $\tau_{\tilde{f}r}^s = 1$), the climate policy is only directly applied to the regulated sectors, while the indirect price effect is transmitted to the global fuel market through the non-regulated fuel sector $\tilde{f}$. The regulated fuel sector also ensures that regulated fuel users in country r do not buy unregulated fuels on the world market.

In line with Caron and Fally (2022), the model distinguishes between a *primary fuel sector* and a *secondary fuel sector*. The primary fuel sectors correspond to the extraction of raw materials (*Mining and quarrying*), which need to be processed before being burned by their final user (e.g., crude oil needed to be refined in gasoline). The secondary fuel sector (*Manufacture of coke and refined petroleum products*) covers the transformation of the fuel and its supply to the final users. In order to avoid double-counting the emissions from fuel combustion, only the usage of secondary fuels by non-fuel sectors is considered for evaluating the emission intensity of fuel use, and only the use of the regulated secondary fuel is covered by the fuel input tax. In the production function for the secondary fuel, the primary fuel can be sourced from anywhere in the world (i.e., Equation A. 19 applies within but not between primary and secondary fuels).

¹ This property ensures that the regulated fuel markets are fully coupled with the corresponding non-regulated fuel markets: following equation II, the price index of the regulated fuels follow the price index of the non-regulated fuel markets, multiplied by the potential carbon tax on fuel use. Furthermore, the size of the non-regulated fuel markets are conserved when introducing a regulated fuel sector. A direct consequence of this property is that the fuel sectors are excluded from the subset of sectors covered by the carbon price $\bar{J}$, i.e. emissions are only priced when fuels are being burned in the rest of the economy. Practically, it means that the direct emissions from fuel manufacturing (e.g. refining emissions) are accounted downstream in the supply chain, when the fuels are being burned by non-fuel sectors.

A.5 Computation of the embodied emissions

The computation of the embodied emissions in products traded from/to the regulated zone Ω to/from the unregulated zone $\bar{\Omega}$ depends on the number of supply chain layers considered. The direct emission intensity of the product j produced in country s , φ'_{js} , combines the process emission intensity of product j in country s , (direct process emissions, e_{js}) and the emission intensity from direct fuel use, φ'^f_{js} . The fuel emission intensity is proportional to the value of fuel f used by the sector j in country s , multiplied by the emission intensity of the fuel f in country s , e^s_f . The fuel share in quantity derives from the nominal expenditure share of fuel f in the production function of js , γ'^{js}_f , divided by the fuel price change in country s , $\hat{p}^s_f$. The intensity of embodied emissions of rank 1 is then obtained by summing the emission intensities of all fuels available and the direct process emissions:

$$\varphi'_{js} = \sum_f \frac{\gamma'^{js}_f}{\hat{p}^s_f} e^s_f + e_{js}. \quad (\text{A. 20})$$

We denote the contribution of input i from country r to the embodied emissions of one unit of output of product j produced in country s by $(\eta'^1)_{ir}^{js}$. At each supply chain stage, we assume that the emissions embedded in products are proportional to the value shipped (in basic price), no matter the destination. $(\eta'^1)_{ir}^{js}$ then corresponds to the direct emission intensity of input i in country r multiplied by the real input share of ir in the production function of industry j in country s , β'^{js}_{ir} :

$$(\eta'^1)_{ir}^{js} = \beta'^{js}_{ir} \varphi'_{ir}. \quad (\text{A. 21})$$

The real input share of the input i from country r in the production function of j in s , β'^{js}_{ir} depends on the price index of the input i in country s , $\hat{p}^s_i$, and the nominal input share of ir in js , is obtained by dividing the nominal value by the price index change of input i in country s , γ'^{js}_{ir} :

$$\beta'^{js}_{ir} = \frac{\gamma'^{js}_{ir}}{\hat{p}^s_i}. \quad (\text{A. 22})$$

Finally, the counterfactual input share derives from the fixed expenditure share of js in i , γ'^{js}_i , multiplied by the counterfactual trade share of country r in providing i to country s , net of taxes and subsidies:

$$\gamma'^{js}_{ir} = \frac{\widehat{\pi^s_{ir} \pi^s_{ir}}}{\widehat{\tau^s_{ir} \tau^s_{ir} \zeta^s_{ir} \zeta^s_{ir}}} \gamma'^{js}_i. \quad (\text{A. 23})$$

The indirect embedded emission intensity from all direct suppliers to sector j in country s , η'^1_{js} , is then the sum of the emission intensities of the inputs from all the regulated sectors $i \in \bar{J}$ in unregulated countries $r \in \bar{\Omega}$ in the case of Import Adjustments, or in regulated countries $r \in \Omega$ in the case of export rebates:

$$(\eta'^1_{js}) = \sum_{i \in \bar{J}} \sum_r (\eta'^1)_{ir}^{js}. \quad (\text{A. 24})$$

The procedure can be extended to any rank of supplier k : for this purpose, we introduce the matrix of real input shares, B' , the array of rank 1 emissions H'^1 and the array of emission intensities Φ' . With these notations, equation A. 24 becomes:

$$H'^1 = B' \Phi'. \quad (\text{A. 25})$$

The emission intensity of indirect inputs of rank k , H'^k , is then obtained by taking the $k - th$ power of the matrix of real inputs:

$$H'^k = (B')^k \Phi'. \quad (\text{A. 26})$$

In the matrix form, setting the coefficients corresponding to non-covered sectors and countries to zero in the array Φ allows discriminating between the sectors and countries that should and should not be included in the calculation of the emission intensities.

Vertical coverage (Ranks of supply chains covered)	Embodied emissions (ϵ'_{ir})	Reference (Equation)
Direct coverage	φ'_{js}	A. 20
Rank n coverage	η'_{js}^k	A. 26
Comprehensive coverage	η'_{js}^∞	A. 28
Comprehensive coverage with import adjustments and in absence of export rebates	$\varphi'_{js} + \eta'^{* \infty}_{js}$	A. 29

Table A. 1: **Overview of the equation used to compute the embedded emissions in imports and exports under different vertical coverage settings.** Each row corresponds to different options of vertical coverage, i.e. different layers of supply chains considered. The equations defining the different variables are denoted in parentheses.

Accounting for all the indirect emissions related to the production of j in s is done by using the Leontief inverse L' , defined from the matrix of real input shares B' and the identity matrix I :

$$L' = (I - B')^{-1}. \quad (\text{A. 27})$$

Coefficient l'^{js}_{ir} captures the real quantity of input i from country r required directly and indirectly to produce one unit of real output j in country s . The emission intensity embodied indirectly in product j from s , η'^{∞}_{js} , is then (note that we subtract 1 from the Leontief coefficient to subtract the direct emissions):

$$\eta'^{\infty}_{js} = \sum_{i,r} (l'^{js}_{ir} - 1) \varphi'_{ir}. \quad (\text{A. 28})$$

Finally, applying import adjustments without export rebates with a comprehensive vertical coverage leads to double-counting the emissions from supply chains looping through the regulated economy (Beaufils et al., 2023a). In that specific case, we use the Throughflow Based Accounting (TBA) method defined in (Beaufils et al., 2023a) to avoid applying the adjustments multiple times to a single source of emissions. The TBA requires defining a matrix B'^* , where all input and output shares related to countries applying the climate policy are set to 0. The modified Leontief inverse L'^* describes the direct and indirect input requirements *in the absence of* the regulating countries, i.e. the supply chains that did not involve the regulated economy in earlier stages. Such modified embodied emission intensity, $\eta'^{* \infty}_{js}$ is finally defined as:

$$\eta'^{* \infty}_{js} = \sum_{i,r} ((l'^{*})^{js}_{ir} - 1) \varphi'_{ir}. \quad (\text{A. 29})$$

Table A. 1 summarises the relations required to compute the Import Adjustments and Export Rebates with different depths of emission accounting.

A.6 Calibration of the emission intensities

The quantity of fuel used by non-fuel sectors², derive from the value of the gross production of the non-fuel sectors, $(x_{ir})_{i \notin F}$, their fuel input shares γ_f^{ir} and the domestic price of the fuel p_f^r :

$$q_f^r = \frac{1}{p_f^r} \left(\sum_{i \notin F} \gamma_f^{ir} x_{ir} \right), \quad (\text{A. 30})$$

in which the gross production x_{ir} (in basic prices) derives from the expenditures in purchaser's price as follows:

$$x_{ir} = \sum_s \frac{\pi_{ir}^s}{\tau_{ir}^s \zeta_{ir}^s} x_i^s. \quad (\text{A. 31})$$

We denote by E_f^r the emissions caused by the burning of the secondary fossil fuel f in country r . In every country r , the real emission intensity of fossil fuel f , $\bar{e}_f$ corresponds to the total emissions from fuel use f in country r , E_f^r , divided by the quantity of fuel f used in country by non-fuel sectors in the baseline equilibrium, q_f^r :

$$\bar{e}_f = \frac{E_f^r}{q_f^r}. \quad (\text{A. 32})$$

Assuming that the real fuel intensity is the same in all countries, we do not need to observe the fuel prices to derive the baseline nominal emission intensities e_f^r . Combining Equations A. 33 and A. 30, the domestic emission intensity per value of fuel used is:

$$e_f^r = E_f^r \left(\sum_{j \notin F} \gamma_f^{jr} x_{jr} \right)^{-1}. \quad (\text{A. 33})$$

Likewise, the baseline nominal process emission intensity of products of p in country r , e_{pr} is the ratio between the emissions of that process, E_{pr} and the output of sector p in country r , x_{pr} :

$$e_{pr} = \frac{E_{pr}}{x_{pr}}. \quad (\text{A. 34})$$

²In order to avoid double counting the emissions of internationally traded fuel, we consider that fuel emissions are only released when fossil fuels are being used by non-fuel sectors. In consequence, the use of fuel by other fuel sectors is not covered by the carbon price - and thus not considered when estimating emission intensities. Note that the emissions that are caused by the fuel sectors (e.g. through oil refining) are still embodied in the total emissions and the emission intensity, but the responsibility for these emissions is allocated to the downstream users of fuels. See section A.4 in the Supplementary Materials.

B Mechanisms analysis

In this section, we analyse in details the cost and effectiveness of the climate policy in the absence of policy response from non-EU countries, under alternative CBAM scopes designs (Section B.1), carbon price level (Section B.2), trade elasticities (Section B.3) and production functions (Section B.4). This exercise supports our interpretation of the sensitivity of the coalition building potential of the EU CBAM presented in the main manuscript (Sections 3.2 and 3.3).

B.1 CBAM extensions

CBAM implementation	Emission reduction in the EU (MtCO ₂)	Global emission reduction (MtCO ₂)	Carbon leakage (%)
None (EU ETS only)	505	305	40
EU CBAM	471	399	15
wide CBAM	457	436	5
deep CBAM	437	476	-9
comprehensive CBAM	435	480	-10
CBAM with ER	421	424	-1

Table B. 1: **Effect of different EU CBAM implementations on emissions in the European Union and at the global level.** We assume here that the CBAM is applied in the EU only, in addition to the EU ETS.

When implemented by the EU alone, all the implementation options of the EU CBAM yield comparable emission reduction in the EU, ranging between 421 and 471 Mt of CO₂ (Table B. 1). The observation in the main manuscript (Section 3.1) that the EU CBAM reduces the level of emission reduction in the EU compared to an ETS-only scenario holds across all CBAM implementations. More stringent CBAM designs even reinforce this effect: while the main EU CBAM scenario reduces EU emission reduction by 7% compared to the ETS alone, this ratio reaches 14% for a comprehensive CBAM and 17% for the CBAM with Export Rebates.

When accounting for carbon leakage and emission changes in the rest of the world, the range of emission reduction widens between different implementation options. While an EU ETS without an anti-leakage instrument only abates 305 MtCO₂ globally (40% leakage), a comprehensive CBAM reaches 480 MtCO₂ of emission reduction, with a -10% leakage rate. Such negative leakage rate is driven by the strong decline in demand for emission-intense products. Under a comprehensive CBAM, the relatively cleaner EU producers gain a competitive advantage over their international competitors on the EU market. The production losses for the emission-intense sectors are thus largely outsourced to trade partners, and these output losses translate into a slight reduction in emissions outside the EU. The EU CBAM currently planned has a narrow scope which does not fully shield the EU producers from upstream and downstream leakage, such that most of the output reduction for the CBAM sectors occur in the EU in the main EU CBAM scenario (see Figure B.1 for illustration).

Taken in isolation, the deep and wide extension options yield similar effects, both in terms of global emission mitigation (476 MtCO₂ and 436 MtCO₂ emission reduction, respectively), but only the deep extension levels the playing field for the CBAM sectors well enough to generate negative leakage (-9%, compared to 5% for the wide CBAM).

The wide extensions of the EU CBAM lead to an increase of the income in the EU compared to the current EU CBAM (Figure B.2). In comparison, the deep CBAM extension has a neutral effect on the EU income, mostly because of the higher leakage rate for the secondary manufacturing sectors (Figure B.1. green bars). In absolute terms, the more ambitious CBAM implementations could make the EU climate policy domestically income-improving: the wide CBAM option (purple square in Figure B.2) increases the aggregated incomes in the EU by 0.002% and the comprehensive CBAM increases EU incomes by 0.007%. In the rest of the world, the extensions of the CBAM are all associated with a decrease in income (reaching -0.05% for a comprehensive CBAM) and in emission level compared with the basic EU CBAM. Although the deep CBAM has a negligible effect on the EU real income, its effect on trade partners is almost as high as the comprehensive CBAM.

However, even if the comprehensive CBAM leads to negative carbon leakage, it does technically not fully shield the EU from output leakage. Instead, Figure B.1 shows that the more comprehensive implementation options of the EU CBAM partially shift the output leakage for the CBAM sectors to more downstream, secondary manufacturing sectors. Effectively, the comprehensive EU CBAM reduces the EU production of secondary manufactured products more than CBAM sectors: these secondary manufactured sectors have essentially no direct emissions and are therefore completely out of the scope of the EU climate policy instruments.

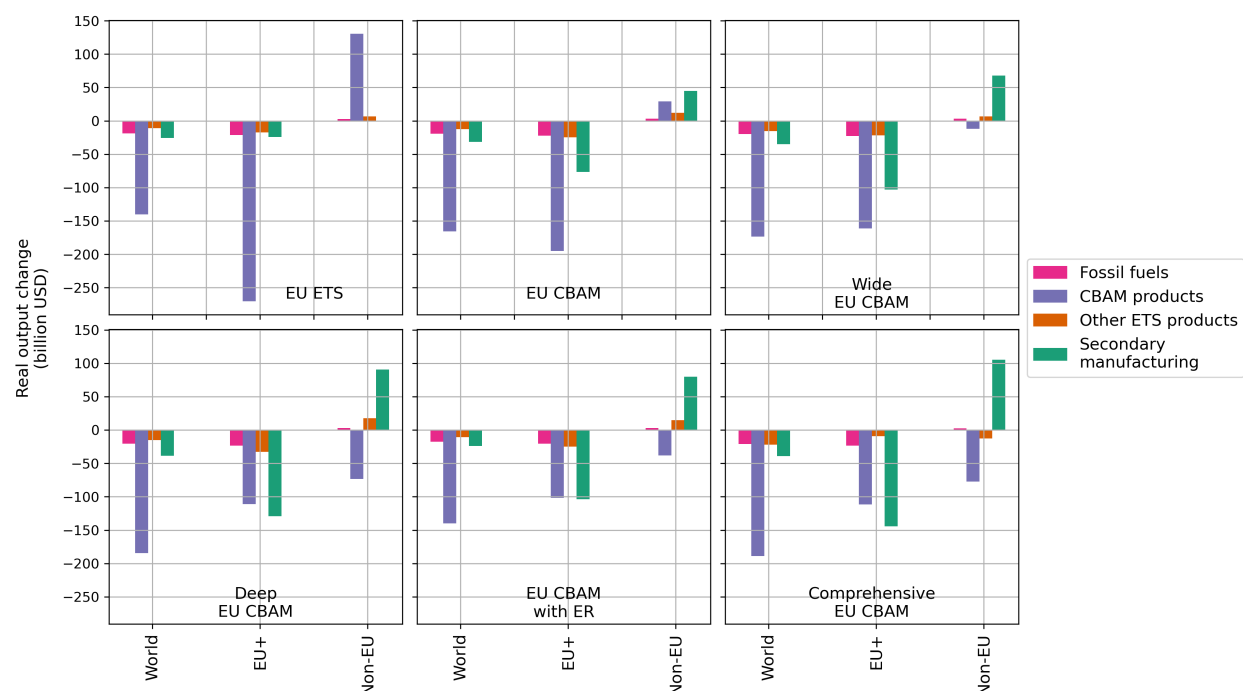


Figure B.1: **Effect of different EU CBAM designs on real output change in and outside the EU.** Each panel shows the effect of the EU climate policy on the real production of selected sectors in the EU, within the EU and globally. The colours correspond to different sector categories. The fossil fuel products (pink) correspond to the manufactured fuels. The CBAM products (purple) are those explicitly covered by the EU CBAM (Table D. 4). The other ETS products (orange) are products of sectors covered by the EU ETS (see D. 3), but not by the main EU CBAM. The secondary manufacturing sectors (green) correspond to all the manufacturing sectors that are neither fuels nor covered by the EU ETS.

The combination of the EU ETS and the EU CBAM increases the price of inputs in the EU and simultaneously contracts the primary income value (orange and green bars in fig B.3, respectively). In the absence of the CBAM, the primary income channel dominates: the economic leakage is high, such that EU consumers can respond to the climate policy by increasing their imports of emission-intense goods and mostly evade the price increases from the climate policy. In turn, the reduction in domestic production makes the primary income reduction the main loss channel under the ETS.

With the EU CBAM, the economic leakage is reduced, making the price effect more important. Meanwhile, the partial levelling of the playing field reduces the competitiveness losses for EU producers, keeping the primary income level relatively higher. Extensions of the CBAM to more products and indirect emissions reinforce this effect. Under the comprehensive CBAM, the EU producers of emission-intense products become relatively more competitive than most trade partners, which essentially cancels the primary income decrease. However, the complete levelling of the playing field forbids any avoidance of the price effect, which eventually constitutes the main channel of economic distortion under a comprehensive CBAM. In turn, this major increase in the EU price index implies steep indirect competitiveness losses for secondary manufacturing sectors in the EU: paradoxically, it is under a comprehensive EU CBAM that the economic losses on emission-neutral, secondary manufacturing sectors are the largest (Figure B.1).

The Export Rebates have a similar effect on output leakage as the CBAM scope extensions, at a higher cost for the EU (see Figure B.2). The Export Rebates only compensate EU exporters of CBAM products from the carbon price directly paid, but do not offset the global increase in input prices indirectly caused by the climate policy (Jakob and Mehling, 2025).³ Therefore, Export Rebates only partially level the playing field on exports, both for the CBAM goods and downstream products (Figure B.1). At the same time, the financing of the export rebates fully drains the fiscal revenue from the EU CBAM, making this policy option relatively less attractive than a CBAM alone (see Figure B.3).

³Note that the literature that does not consider trade interlinkages (see, e.g., Ambec et al., 2024)) cannot identify this incomplete protection from export leakage.

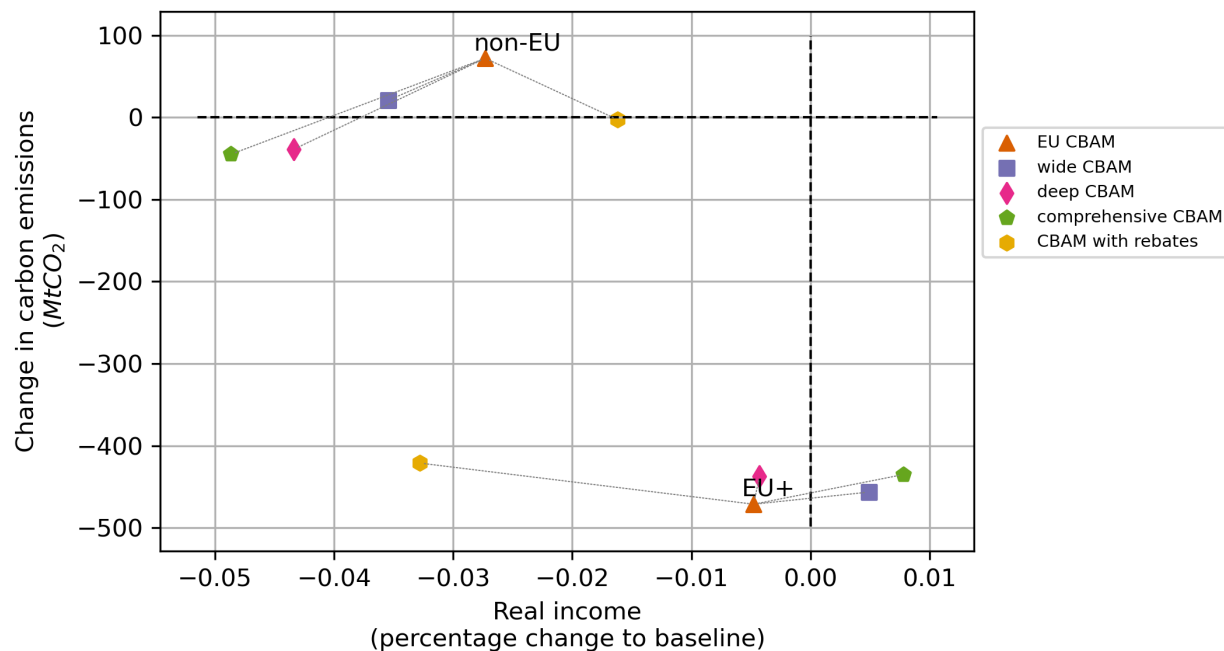


Figure B.2: Assessment of the effect of different EU CBAM implementation options on emissions and real incomes in the EU and in the rest of the world. The orange triangles indicate the emission reduction (y-axis) and the real income change (x-axis) associated with implementing the EU CBAM, in the EU and outside the EU. The coloured markers indicate the comparative outcomes with different extension options: a CBAM covering all the sectors included in the EU ETS (wide CBAM - purple squares), a CBAM covering all upstream emissions of the products covered by the EU CBAM (deep CBAM, pink diamonds), a comprehensive CBAM covering all upstream emissions of all the industries covered by the EU ETS (green pentagons) and an EU CBAM with export rebates relieving the EU exports from the carbon tax (yellow hexagons). All policy instruments assume a carbon price of 100 USD/tCO₂ and no policy response of the EU trade partners.

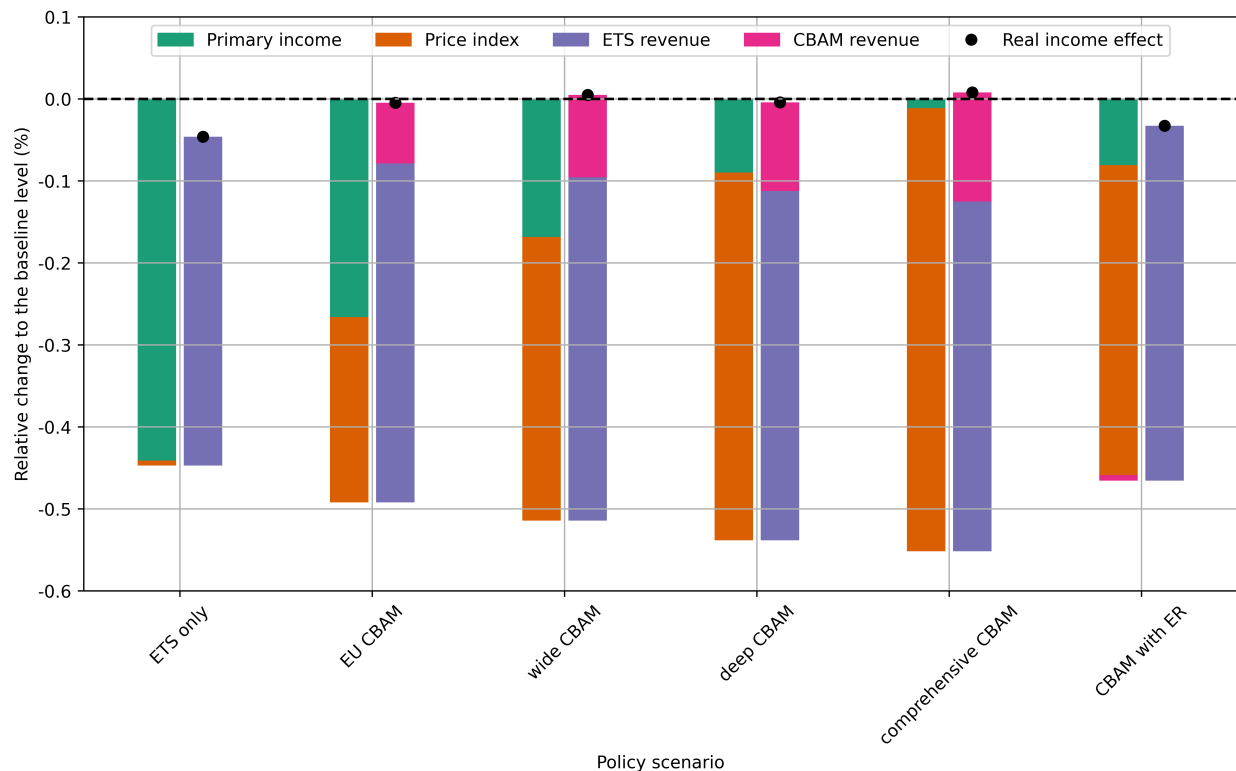


Figure B.3: **Income and price effect of the EU CBAM under different implementation options.** The effect on real incomes is shown with a black dot for the different EU climate policy mixes, in the absence of a carbon price in non-EU countries. Numerical values are obtained by a log-decomposition of Equations 9 and V.

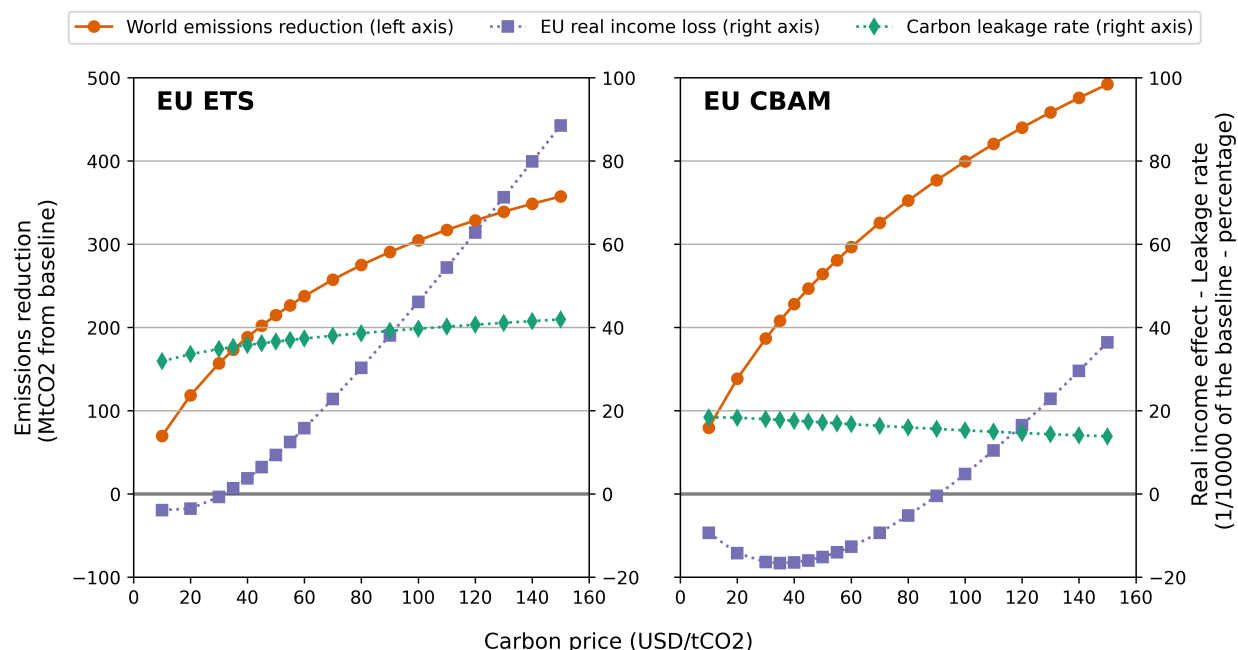


Figure B.4: **Effect of the carbon price level on the cost and effectiveness of the unilateral EU climate policy.** The left and right panels show the effect of the EU carbon level on key outcomes of the EU climate policy, for the EU ETS alone (left panel) and the EU ETS combined with the EU CBAM (right panel). In both cases, the climate policy is applied in the EU alone, and all other countries are assumed not to implement climate policies. Real income and emission reduction are shown in reference to the baseline equilibrium, without ETS nor CBAM.

B.2 Carbon price level

The carbon price plays a key role in the cost and effectiveness of the EU climate policy. Figure B.4 shows how the EU real income, the world emissions and the carbon leakage rate change with the carbon price. For low carbon prices, the EU effectively benefit from both the EU ETS (left panel) and the EU CBAM (right panel) in terms of real income (blue squares). The EU is a net importer of fossil fuels, such that the imposition of a tax on fuel use improves its terms of trade (Farrokhi and Lashkaripour, 2025). However, the carbon price also comes with a distortive effect. As the carbon price increases, the losses due to distortion eventually dominate the terms of trade gains and lead to economic losses in the EU. The point at which the income losses outweigh the trade gains depends on the climate policies. Under the ETS alone, the carbon price becomes income-decreasing above 30 USD/tCO₂. With the EU CBAM, the cut-off increases to 90 USD/tCO₂, thereby highlighting the relative effectiveness of the EU CBAM for limiting the domestic cost of the EU climate policy.

In terms of emission reduction, increasing the carbon price monotonously reduces global emissions (orange dots), but the marginal emission reduction rate decreases with the carbon price, reflecting the convex costs of climate mitigation. The inflexion of the marginal reduction rate is more important for the EU ETS alone than for the EU CBAM. This difference is related to changes in carbon leakage (green diamonds). Under the ETS regime, the leakage rate increases with the carbon price. As the emission price increases, the competitiveness of EU producers degrades, and the reduction in emissions in the EU is more largely compensated by emissions abroad. Under the EU CBAM regime, the relation inverts and the leakage rates reduce with the carbon price. Unlike the ETS scenario, the EU consumers subject to the CBAM cannot evade the carbon price by importing emissions-intensive goods from abroad.

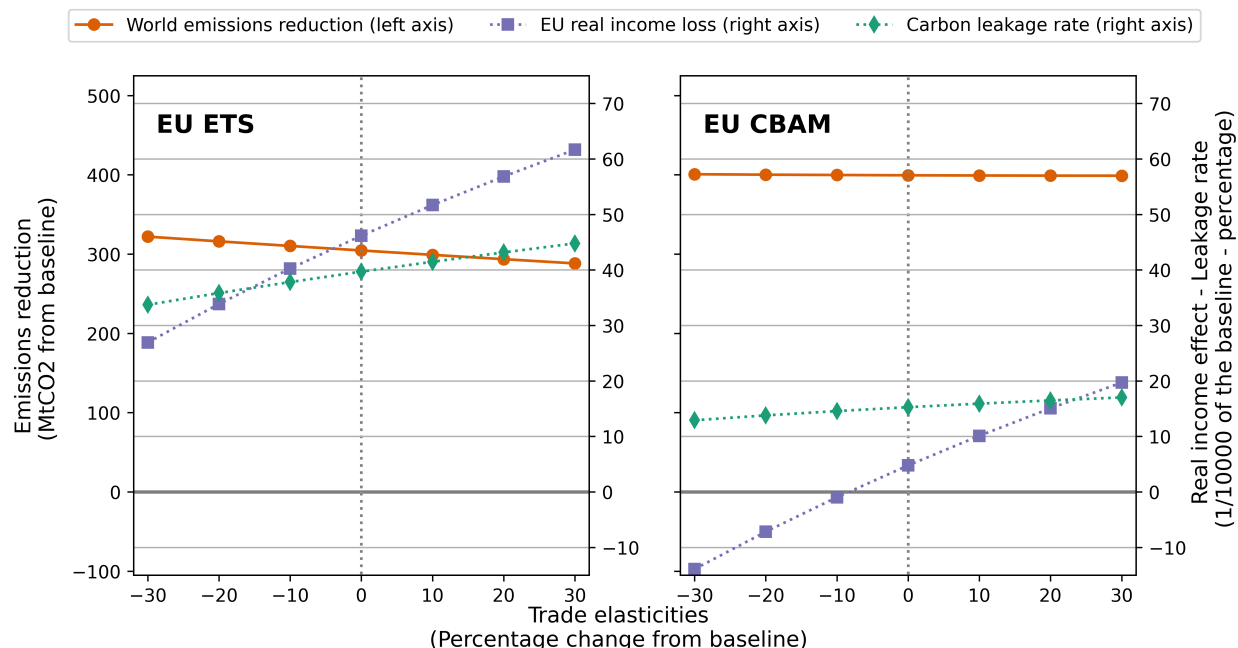


Figure B.5: **Effect of the trade elasticities on the cost and effectiveness of the unilateral EU climate policy.** The left and right panels show the effect of a variation in the sectoral trade elasticities on key outcomes of the EU climate policy, for the EU ETS alone (left panel) and the EU ETS combined with the EU CBAM (right panel). In both cases, the climate policy is applied in the EU alone, and all other countries are assumed not to implement climate policies. Real income and emission reduction are shown in reference to the baseline equilibrium, without ETS nor CBAM.

B.3 Trade elasticities

Under the EU ETS (left panel of Figure B.5), most of the emission reduction are driven by local production changes, such that varying the trade elasticities only has a marginal effect on the level of emission reduction triggered by the EU climate policy (orange dots). Still, increasing trade elasticities makes it easier for the EU trade partners to shift their trading patterns in response to the EU climate policy, such that higher trade elasticities translate both in larger income losses for the EU (purple squares) and a slightly larger carbon leakage rate (green diamonds).

Under the combination of the ETS and the EU CBAM (Figure B.5, right panel), changes in trade elasticities affect global emissions in two ways. On the one hand, higher trade elasticities allow for more effective selection of the cleanest producers on the EU market, making the EU CBAM more effective at reducing emissions. On the other hand, higher trade elasticities also allow importers from the EU to better reshuffle their imports, thereby increasing carbon leakage (green diamonds). Overall, these two competing effect cancel each other, such that the volume of global emission reduction (orange dots) is remarkably insensitive to the change in trade elasticities. Still, the income losses for the EU are still largely driven by the level of trade elasticities (purple squares): as for the ETS only scenario, higher trade elasticities magnify the productivity shock of the climate policy on the EU economy by stimulating the market share losses in response to the higher production costs in the EU (Equation III).

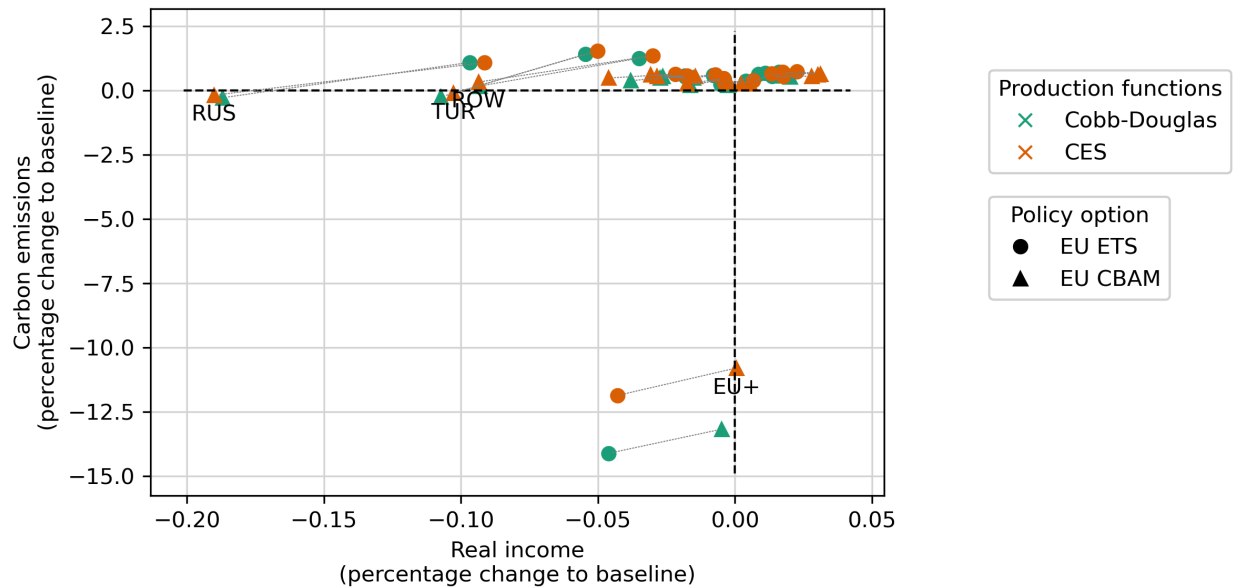


Figure B.6: **Comparison of the effect of the EU climate policy on the emissions and real incomes under alternative model specifications.** The orange data points show the effect of the EU ETS (orange dots) and the combination of the EU CBAM with the ETS (orange triangles) in the main specifications of the trade model (see Section 2.1.2 for the model description and Figure 1 for reference). The green data points show the effects under the same policy scenarios when replacing the Cobb-Douglas production functions by Constant Elasticity of Substitution, as described in Section A.2.

B.4 Production functions

Section A.2 introduces an alternative specification of the trade model (Section 2.1.2). Compared to the baseline Cobb-Douglas implementation used in the main specifications, the quantitative and qualitative effects of the EU CBAM are largely preserved when using Constant Elasticity of Substitution (see Figure B.6).

The elasticity of substitution between intermediate inputs (Figure B.7, left column) controls how easily intermediate and final consumers can reduce their use of fossil fuels and emission-intensive inputs by other intermediate or final inputs. For very low elasticities of substitution, the producers in the EU cannot effectively reduce their emission intensity and the demand for emission-intensive products is mostly left unaffected by the climate policy. In the absence of an EU CBAM (top left panel), this leads to a massive leakage rate (green diamonds), which exceeds 100% in the Leontief case (0 elasticity of substitution). In this case, the demand for these products remains constant and the EU consumers can easily circumvent the EU climate policy by substituting domestic by imported products: the output losses in the EU are therefore fully compensated by production increases abroad. Because non-EU producers often have higher emission-intensity than their EU counterparts, the EU ETS leads in the most rigid case to a leakage rate above 100%, i.e., overall emission increases (orange dots). For higher substitution elasticities between intermediates, consumers within the EU are able to partially substitute the most emission-intensive intermediate and final goods with cleaner inputs and consumption goods, thereby decreasing the leakage rate and increasing the overall emission reduction level. Still, a higher flexibility in the use of intermediate inputs also allows the EU competitors to better adjust to the competitiveness shock induced by the climate policy, which increases the real income losses for the EU.

The same mechanisms affect the EU real income and the emission reduction level under the EU CBAM (lower left panel). Under the low substitutability regime, the leakage rate is relatively high because the demand of emission-intensive goods is largely inelastic. However, in this case, the CBAM partially succeeds in protecting the EU market from international competition, thereby limiting the carbon leakage rate to a lower level. For larger substitution elasticities, the carbon leakage rate slightly increases again. As for the EU ETS case, a higher elasticity of substitution allows producers in the EU to better respond to the policy shock, which both increases the volume of overall emission reduction and the real income losses for the EU.

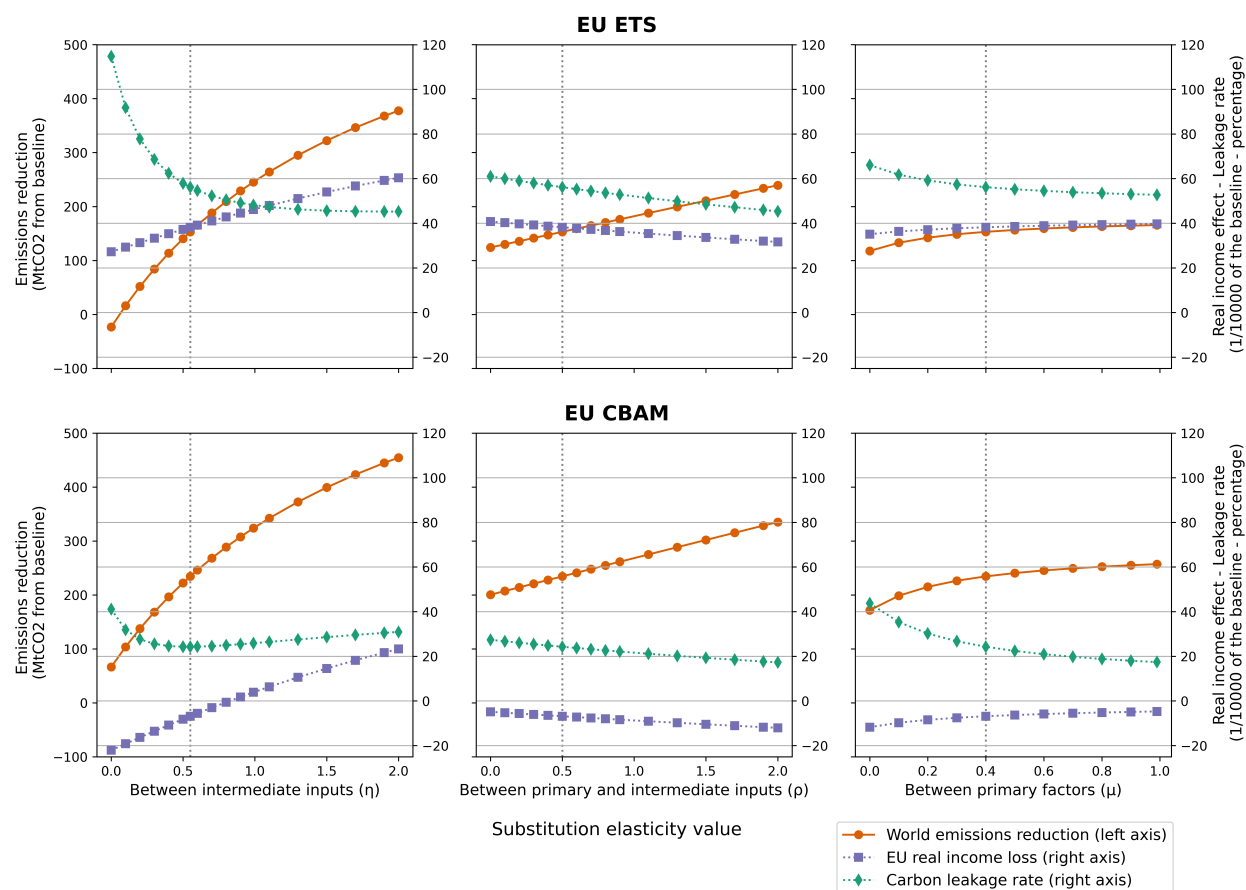


Figure B.7: Effect of the elasticities of substitution on the cost and effectiveness of the unilateral EU climate policy. Each panel shows the effect of a variation in a parameter of the CES implementation of the trade model (see Section A.2) on key outcomes of the EU climate policy. The top row shows the results for the EU ETS alone and the bottom row corresponds to the EU ETS combined with the EU CBAM. In all cases, the climate policy is applied in the EU alone, and all other countries are assumed not to implement climate policies. Real income and emission reduction are shown in reference to the baseline equilibrium, without ETS nor CBAM. The influence of each parameter is assessed independently from the other parameters: the value of the other parameters is kept at a constant value, indicated by a vertical dotted line on the corresponding plot.

The elasticity of substitution between intermediate and primary inputs (central column) also affects the ability of EU producers to reduce their use of emission-intensive products. This parameter plays a similar role under the EU ETS alone (upper central panel) and under the EU CBAM regimes (lower central panel): in both cases, increasing the elasticity of substitution permits EU producers to reduce their emissions by increasing the relative use share of primary factors. This means that emission reduction becomes relatively cheaper as the elasticity of substitution is increased, which simultaneously i) decreases the cost of the climate policy in the EU (EU real income loss, purple squares); ii) reduces the leakage rate (green diamonds) and iii) increases the overall emission reduction effect from the EU climate policy.

Finally, the substitution of elasticity between primary factors influences the possibility for fossil fuel producers to respond to price changes on the fuel market (right column). Under both the ETS and the CBAM regime, a low elasticity of substitution for the natural resource reduces the fuel supply elasticity: fuel producers are less able to reduce their production in response to the fuel demand reduction in the EU, leading to more fuel-driven carbon leakage (Caron and Fally, 2022). A lower elasticity of substitution also makes the climate policy more expensive for the EU (purple squares): the lower response of the fuel market reduces the international fuel prices, which benefits the countries without a climate policy comparatively more than the EU.

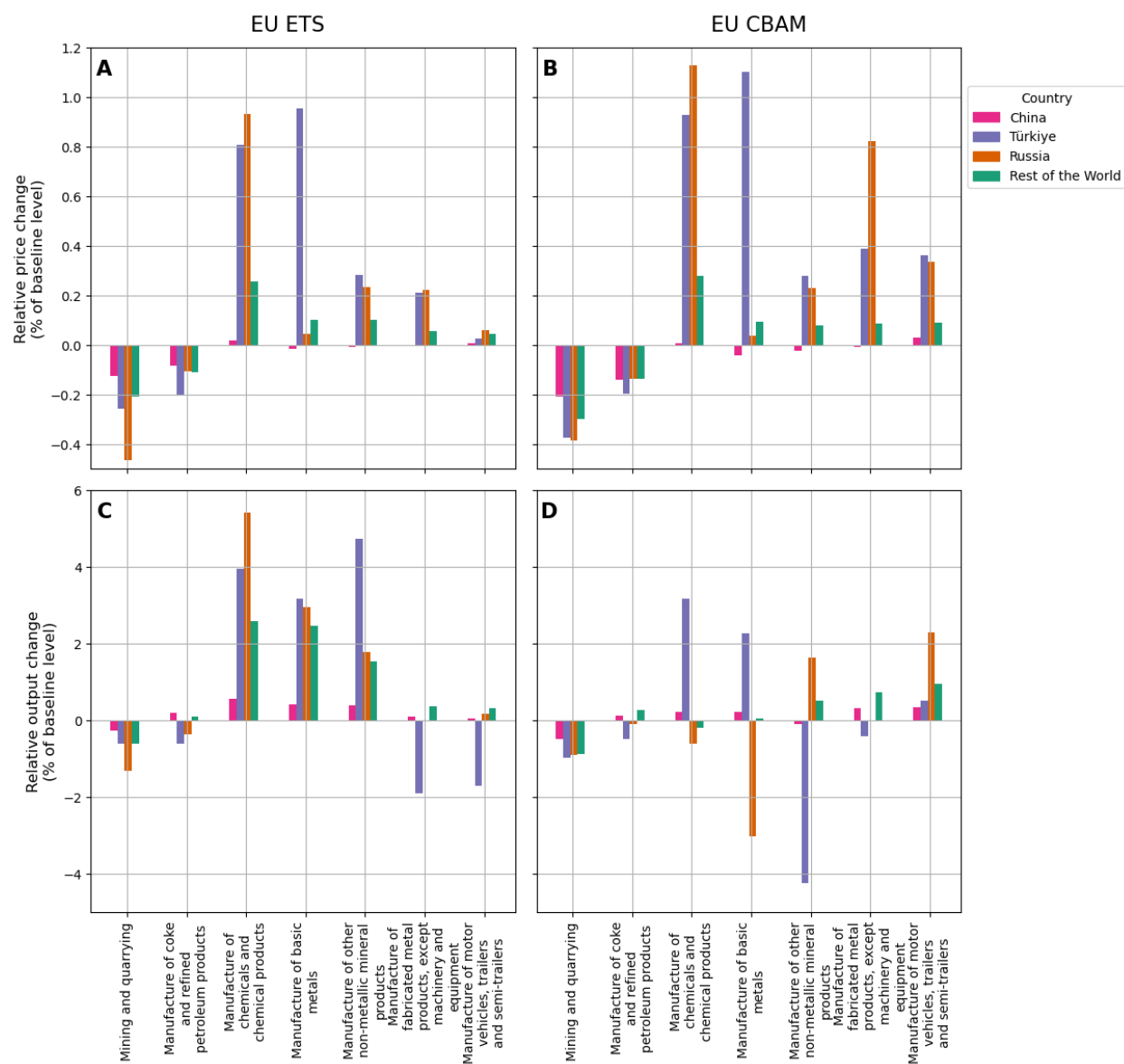


Figure C.1: Effect of the EU climate policy on the consumption price and the output quantity on a selection of trade partners and sectors.

C Additional Figures

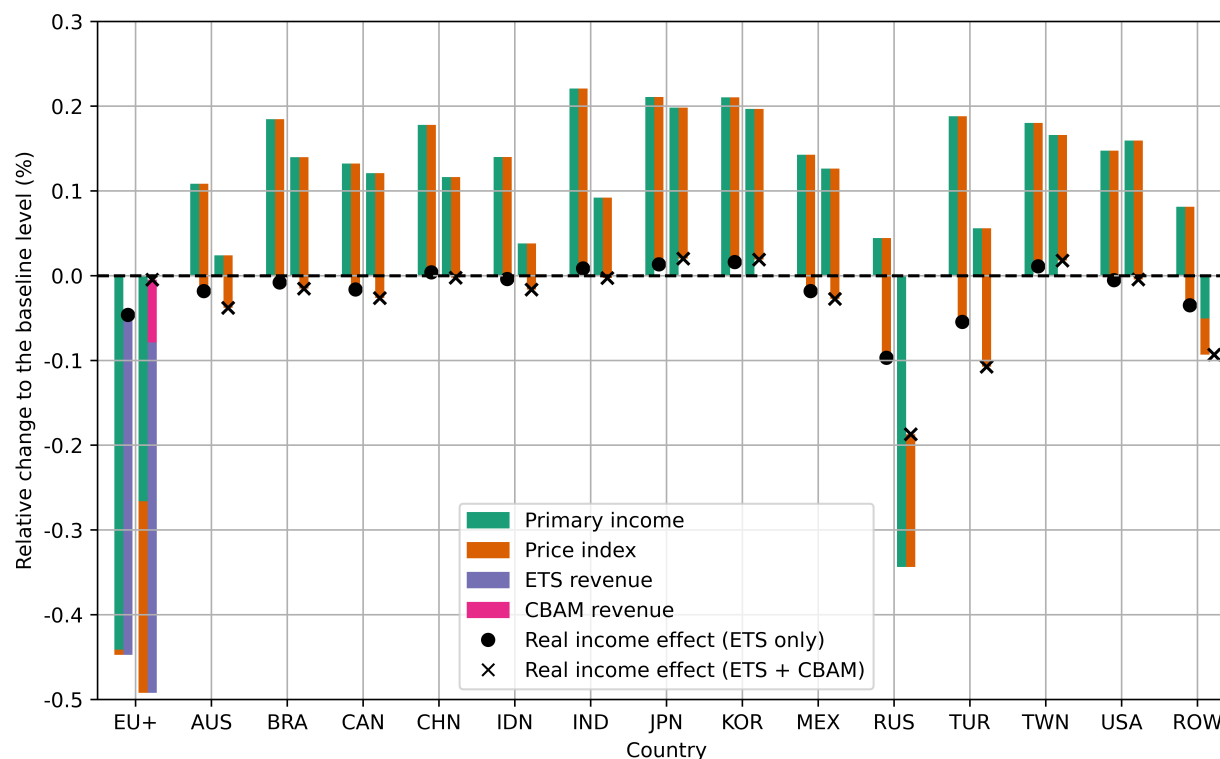


Figure C.2: **Log-decomposition of the real income effect of the EU climate policy.** The EU climate policy affects countries through changes in income (green bars) and price levels (orange bars). In the EU, the carbon price reduces economic activity, which drives both prices and revenues down. The fiscal revenue from the carbon price instruments (purple and pink bars) partially compensates for the activity losses attributable to the climate policy. The other countries are only affected by the price and income effects. The resulting effect on real incomes is shown with a black dot for the EU ETS alone, and with a black cross for the EU ETS combined with the EU CBAM. Numerical values are obtained by a log-decomposition of Equations 9 and V.

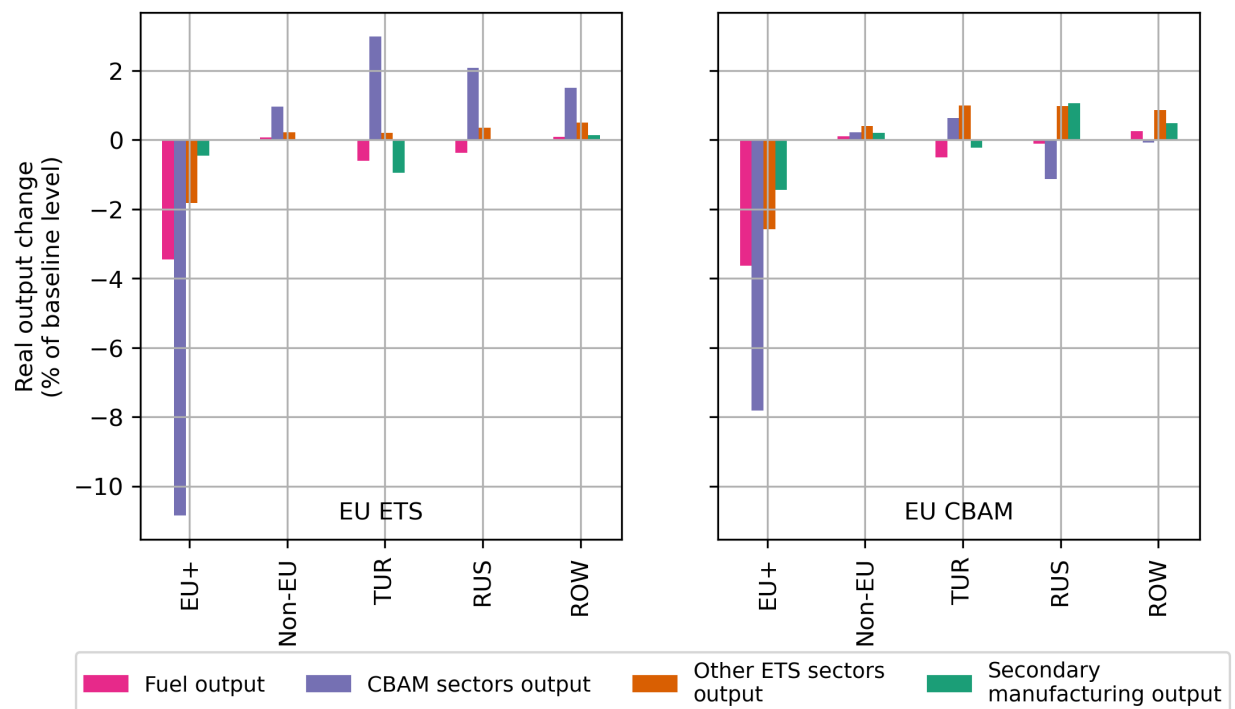


Figure C.3: Effects of the EU climate policy on the production volumes of a selection of sectors.

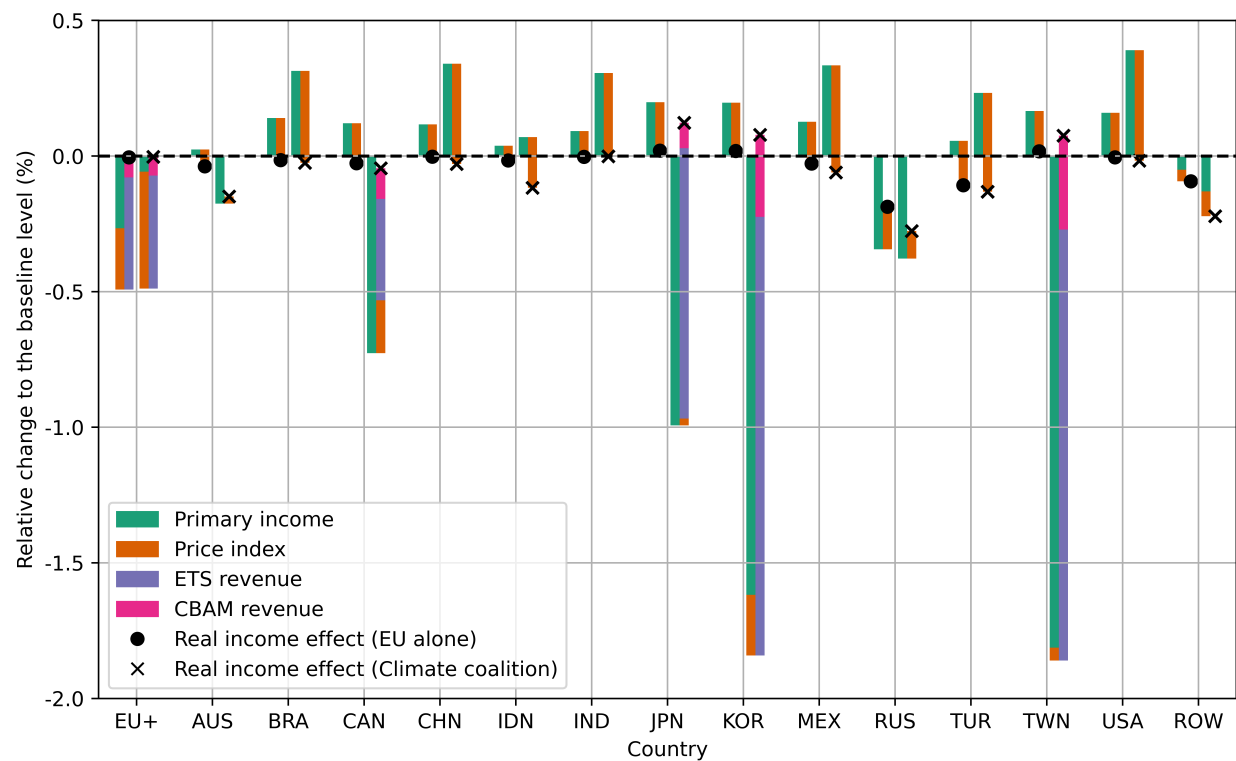


Figure C.4: **Decomposition of the real income effect of the application of an ETS and a CBAM by the EU alone (left bars, dots) or by the countries in the stable coalition arising from the main specification (right bars, crosses).** The contribution of the individual items derives from the log-decomposition of equation 9 and V..

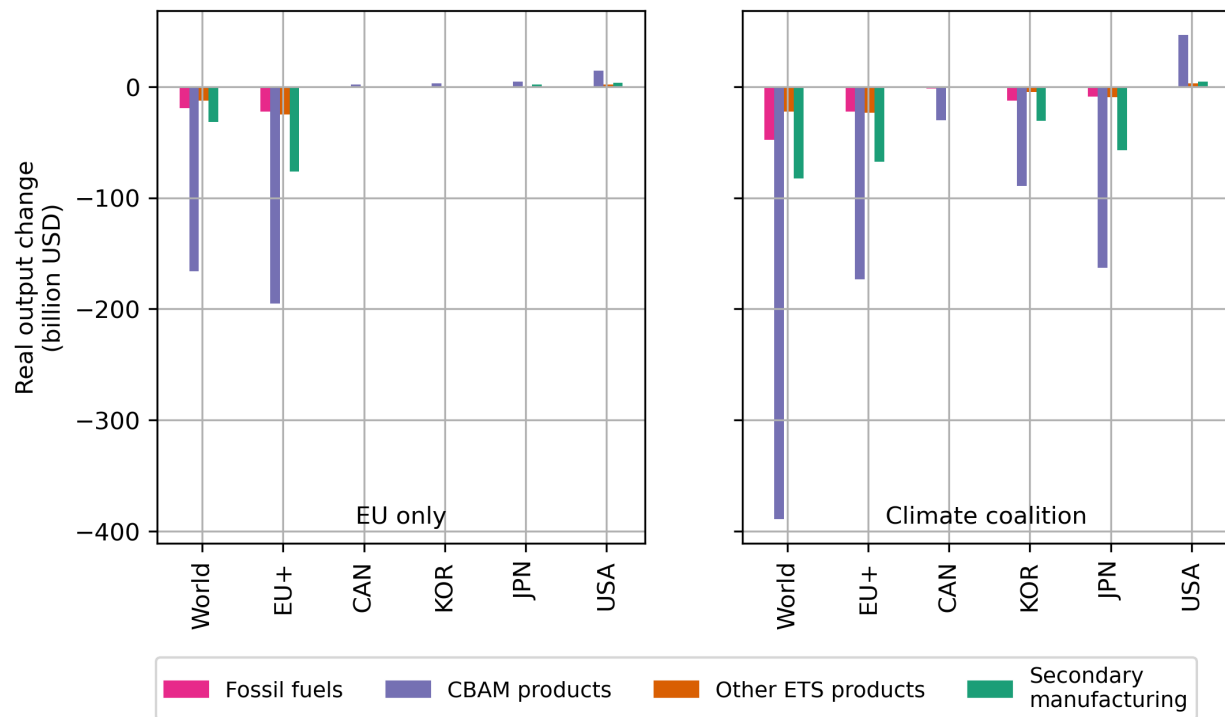


Figure C.5: **Effects of an ETS and a CBAM on the production volumes of a selection of sectors.** In the left panel, the climate policy is applied in the EU only. In the left panel, all the countries from the main specification's coalition (EU, Canada, Japan, Korean and Taiwan, see Section 3.1) apply the climate policy.

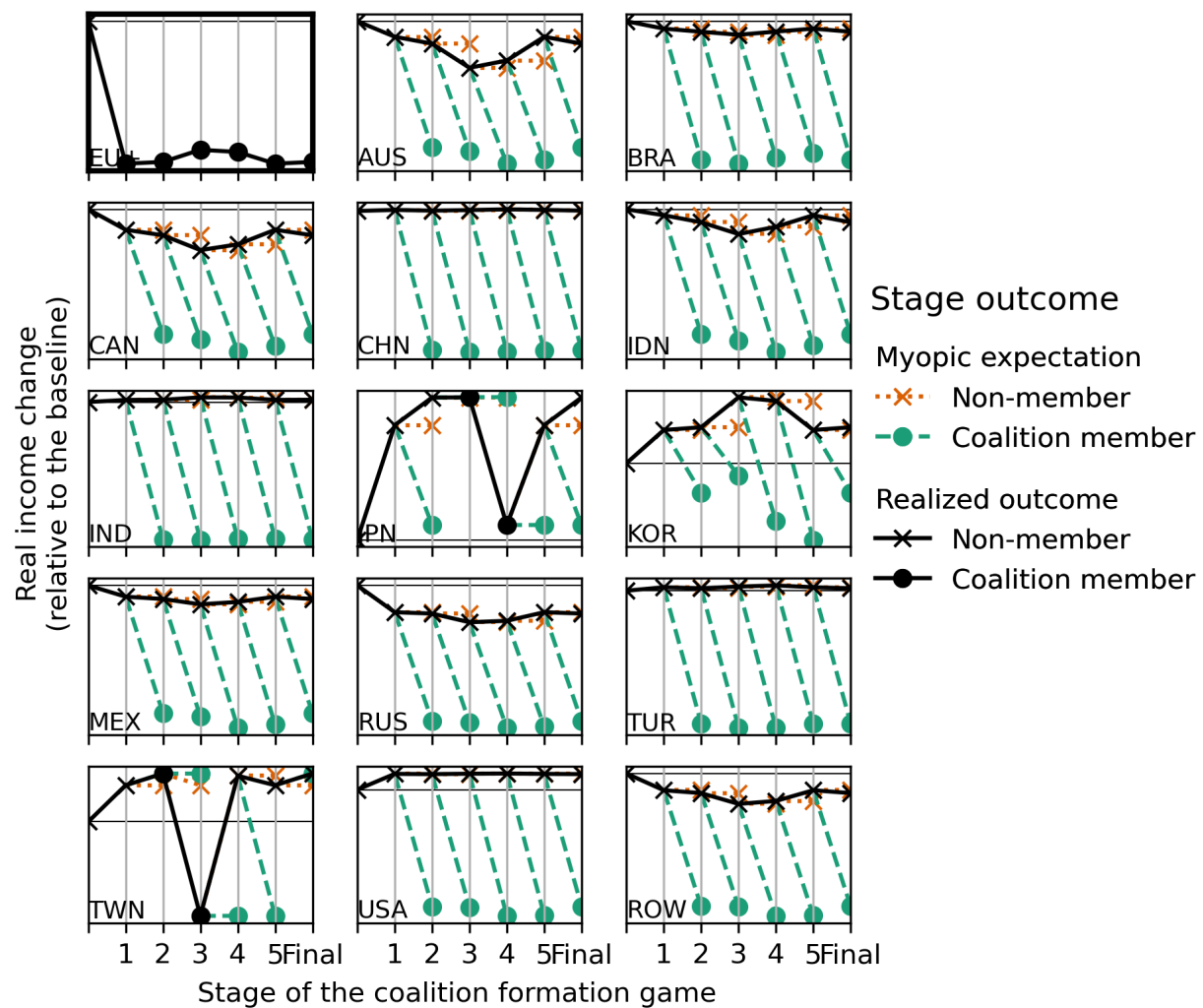


Figure C.6: **Coalition-building process under an EU CBAM with Export Rebates.** In this scenario, the EU commits to the climate policy. At stage 1, Taiwan decides to join the coalition, which triggers the decision of Japan to join the coalition too after the second stage. In turn, the Japanese decision to join the coalition cancels the terms of trade gains from Taiwan, which leaves the coalition in the third stage. This, in turn, cancels the decision of Japan to join the coalition in stage 4. Stage 5 yields an identical situation as step 1: Taiwan is now willing the climate policy again which would again attract Japan in the coalition, again triggering the defection of Taiwan... In the absence of a stable coalition, we arbitrate that neither Taiwan nor Japan join the coalition: there is no stable coalition under the CBAM regime with export rebates. See Figure 3 for the description of the coalition formation game.

Sector	Trade elasticity
Crop and animal production, hunting and related service activities	1.849696
Forestry and logging	0.524987
Fishing and aquaculture	11.978284
Mining and quarrying	13.967205
Manufacture of food products, beverages and tobacco products	4.160160
Manufacture of textiles, wearing apparel and leather products	4.829138
Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	5.333104
Manufacture of paper and paper products	6.047290
Printing and reproduction of recorded media	3.648797
Manufacture of coke and refined petroleum products	3.853128
Manufacture of chemicals and chemical products	5.089583
Manufacture of rubber and plastic products	4.837308
Manufacture of other non-metallic mineral products	6.250054
Manufacture of basic metals	6.822531
Manufacture of fabricated metal products, except machinery and equipment	7.230138
Manufacture of computer, electronic and optical products	4.553235
Manufacture of electrical equipment	5.038077
Manufacture of machinery and equipment n.e.c.	8.015901
Manufacture of motor vehicles, trailers and semi-trailers	9.587023
Manufacture of other transport equipment	3.272053
Manufacture of furniture; other manufacturing	4.307600
Repair and installation of machinery and equipment	4.977730

Table D. 1: **Trade elasticity values used in the main specifications.** Values are reported from Fontagné et al. (2022), as provided in the WIOD resolution. We chose a default trade elasticity of 5 for the non-specified sectors (mostly services). The elasticities in Section 3.3.1 are obtained by increasing all trade elasticity parameters by a coefficient between +30% and -30% (excluding the default trade elasticity).

D Additional tables

Category Code	Economic sector		
1.A.1.a	Electricity, gas, steam and AC		
1.A.1.b	coke and petroleum		
1.A.1.c	coke and petroleum		
1.A.2.a	basic metals		
1.A.2.b	basic metals		
1.A.2.c	chemicals	basic pharmaceutical products	
1.A.2.d	paper and paper products	Printing and reproduction of recorded media	
1.A.2.e	food products		
1.A.2.f	non-metallic mineral products		
1.A.2.g	motor vehicleless	other transport equipment	
1.A.2.h	computer, electronic and optical products	electrical equipment	machinery and equipment n.e.c.
1.A.2.i	Mining and quarrying		
1.A.2.j	wood and of products of wood and cork		
1.A.2.k	Construction		
1.A.2.l	textiles		
1.A.2.m	rubber and plastic products	fabricated metal products	furniture; other manufacturing
1.A.3.a	Air transport		
1.A.3.b.i	Final demand		
1.A.3.b.ii	Land transport		
1.A.3.b.iii	Land transport		
1.A.3.b.iv	Final demand		
1.A.3.c	Land transport		
1.A.3.d	Water transport		
1.A.3.e	Land transport		
1.A.4.a	coke and petroleum		
1.A.4.b	Final demand		
1.A.4.c.i	Crop and animal production	Forestry and logging	
1.A.4.c.ii	Crop and animal production	Forestry and logging	
1.A.4.c.iii	Fishing and aquaculture		
1.A.5	Public administration		
1.B.1.a	Mining and quarrying		
1.B.1.c	coke and petroleum		
1.B.2.a.i	Mining and quarrying	coke and petroleum	
1.B.2.a.ii	Mining and quarrying	coke and petroleum	
1.B.2.a.iii.1	Mining and quarrying	coke and petroleum	
1.B.2.a.iii.2	Mining and quarrying	coke and petroleum	
1.B.2.a.iii.3	Land transport and transport via pipelines		
1.B.2.a.iii.4	coke and petroleum		
1.B.2.a.iii.5	coke and petroleum		
1.B.2.a.iii.6	Mining and quarrying	coke and petroleum	

1.B.2.b.i	Mining and quarrying	coke and petroleum
1.B.2.b.ii	Mining and quarrying	coke and petroleum
1.B.2.b.iii.1	Mining and quarrying	coke and petroleum
1.B.2.b.iii.2	Mining and quarrying	coke and petroleum
1.B.2.b.iii.3	coke and petroleum	
1.B.2.b.iii.4	Land transport and transport via pipelines	
1.B.2.b.iii.5	Electricity, gas, steam and AC	
1.B.2.b.iii.6	Mining and quarrying	coke and petroleum
1.B.3	Electricity, gas, steam and AC	
1.C	Mining and quarrying	
2.A.1	non-metallic mineral products	
2.A.2	non-metallic mineral products	
2.A.3	non-metallic mineral products	
2.A.4	non-metallic mineral products	
2.B.1	chemicals	
2.B.10	chemicals	
2.B.2	chemicals	
2.B.3	chemicals	
2.B.4	chemicals	
2.B.5	chemicals	
2.B.6	chemicals	
2.B.7	chemicals	
2.B.8	chemicals	
2.B.9	chemicals	
2.C.1	basic metals	
2.C.2	basic metals	
2.C.3	basic metals	
2.C.4	basic metals	
2.C.5	basic metals	
2.C.6	basic metals	
2.C.7	basic metals	
2.D	coke and petroleum	
2.E	computer, electronic and optical products	
2.F	Repair and installation	Electricity, gas, steam and AC
2.G.1	electrical equipment	
2.G.2	computer, electronic and optical products	
2.G.3	Final demand	
2.G.4	Final demand	
2.H.1	paper and paper products	
2.H.2	food products	
2.H.3	Final demand	
3	Crop and animal production	Forestry and logging

Table D. 2: **Mapping between UNFCCC emission categories and MRIO sectors.** The left column indicates the process causing emissions, as defined by the United Framework Convention on Climate Change (Gütschow et al., 2021b). The right columns indicate the MRIO sectors to which these emission categories correspond.

Sector covered by the EU ETS
Mining and quarrying
Manufacture of paper and paper products
Manufacture of coke and refined petroleum products
Manufacture of chemicals and chemical products
Manufacture of basic pharmaceutical products and pharmaceutical preparations
Manufacture of rubber and plastic products
Manufacture of other non-metallic mineral products
Manufacture of basic metals
Electricity, gas, steam and air conditioning supply

Table D. 3: **Sectors covered by the EU ETS.** Note that we assume the EU ETS to cover all the direct fuel and industrial emissions from these sectors (see Table D. 2).

Product covered in the EU regulation (European Commission, 2023)	Sector in the MRIO table (Timmer et al., 2016)
Iron and steel	Manufacture of basic metals
Aluminium	Manufacture of basic metals
Fertilisers	Manufacture of chemicals and chemical products
Cement	Manufacture of other non-metallic mineral products
Electricity	Electricity, gas, steam and AC
Hydrogen	NA

Table D. 4: **Sectors covered by the EU CBAM.** The first column shows the sectors explicitly covered by the EU CBAM regulation as implemented in 2023 (European Commission, 2023). The second column shows the equivalent sector in the MRIO Table (Timmer et al., 2016). Note that Hydrogen is not considered here, as it is currently not traded in significant quantities.

UNFCCC Category code	Emission type	Description
1.A.1.a	Fuel emissions	Electricity and heat production
1.A.2.a	Fuel emissions	Combustion for Iron and Steel production
1.A.2.b	Fuel emissions	Combustion for non-ferrous metals (incl. aluminium)
1.A.2.c	Fuel emissions	Combustion for chemicals (incl. fertilisers)
1.A.2.f	Fuel emissions	Combustion for non-metallic minerals (incl. cement)
2.A.1	Process emissions	Cement production
2.B	Process emissions	Production of chemicals (incl. fertilisers)
2.C.1	Process emissions	Iron and Steel production
2.C.3	Process emissions	Aluminium production

Table D. 5: **Emissions source in the EU CBAM scope.** The nomenclature follows the United Nations Framework Convention on Climate Change (UNFCCC) guidelines (Gütschow et al., 2021b).

Exporter	Non-metallic minerals	Basic metals	Chemicals	Electricity
AUS	0.030	0.136	0.049	0.008
BRA	0.071	0.051	0.017	0.017
CAN	0.037	0.031	0.065	0.005
CHN	0.120	0.104	0.067	0.091
IDN	0.152	0.063	0.083	0.032
IND	0.226	0.104	0.049	0.073
JPN	0.074	0.049	0.035	0.101
KOR	0.138	0.040	0.040	0.082
MEX	0.081	0.053	0.038	0.018
RUS	0.122	0.127	0.109	0.199
TUR	0.200	0.028	0.032	0.069
TWN	0.078	0.027	0.046	0.133
USA	0.047	0.029	0.018	0.037
ROW	0.126	0.110	0.085	0.067

Table D. 6: **Ad-valorem rates of the CBAM price adjustments.** The values correspond to the initial ad-valorem tariff rates applied to the imports of CBAM products from the respective countries to the EU, under the central EU CBAM design that considers the direct fuel and process emissions from the emissions source indicated in Table D. 5, as described in Section A.5. Note that the tariff rates in the counterfactual equilibria depend on the counterfactual production prices (see Equation XI) and might thus differ from the values shown here. The emission data originate from Gütschow et al. (2021b) and Gütschow et al. (2021a) following the mapping method described in Beaufils et al. (2023a) and are calibrated using the procedure described in Section A.6. Note that, while the EU CBAM applies at the product level, data and model limitations only allow modelling emissions at the sector level. The differences in emission intensities between countries arise here both from technology and composition differences. "Non-metallic minerals" is used as a short form of "Manufacture of other non-metallic mineral products", "Basic metals" for "Manufacture of basic metals", "Chemicals" for "Manufacture of chemicals and chemical products" and "Electricity" for "Electricity, gas, steam and air conditioning supply".

Country	EU ETS	EU CBAM	wide CBAM	deep CBAM	Comprehensive with ER	CBAM
EU+	28.8	0.8	0	0.7	0	13.1
AUS	0.8	3.0	3.0	3.0	2.7	1.5
BRA	0.6	0.8	1.0	1.2	0.9	0.3
CAN	0.9	1.1	0.4	0.6	2.0	0.9
CHN	0	4.6	5.8	7.4	7.6	0
IDN	0.1	1.5	1.7	1.7	1.4	0.5
IND	0	0	0.7	0.8	1.1	0
JPN	0	0	0	0	0	0
KOR	0	0	0	0	0	0
MEX	0.7	1.1	1.3	1.3	2.6	0.6
RUS	5.6	7.1	7.2	7.6	6.4	6.1
TUR	1.4	1.5	1.5	2.0	1.7	0
TWN	0	0	0	0	0	0
USA	2.9	4.3	5.8	5.5	4.2	0
ROW	11.9	33.4	35.0	37.6	35.1	21.5

Table D. 7: **Minimum Social cost of carbon value to make the climate coalition income-improving, in USD/tCO₂.** The values represent the minimum National Social cost of carbon (i.e., the value of domestic climate damages avoided) to make the implementation of the coalitions described in Table 1 domestically income-improving. The values are evaluated by dividing the real income losses from implementing the coalitions in Table 1 by the volume of emissions avoided in the corresponding scenario. The values reported in Table 2 correspond to the largest Social Cost of Carbon value **for the countries inside the coalition** and are indicated in bold. Italicized values correspond to countries that do not join the climate coalition in the absence of climate damages (i.e., the countries not in the coalitions shown in Table 1). Negative values are set to 0 since they represent cases where the coalition formation is already income-improving in the absence of climate damages. Note that the gains from the emission reduction in coalition members benefit all countries, even if they do not join the coalition: countries that benefit from the coalition *even in the absence* of climate damages do not necessarily benefit from joining the coalition themselves (Barrett, 1994).