Measuring EU CBAM Incidence at the Product Level: A Multi-country Partial Equilibrium Analysis

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Abstract:

The European Union's Carbon Border Adjustment Mechanism (EU CBAM) applies a carbon price to imports based on embedded greenhouse gas emissions. Existing analyses rely on aggregated sector-level data and emissions intensities expressed relative to trade values, despite liabilities being calculated at the product level. This paper applies a multi-country, product-level partial equilibrium model aligned with the EU CBAM's institutional design to analyse its impact on EU imports of iron & steel and aluminium. It combines country-product emission factors with Combined Nomenclature (CN) 8-digit trade data to simulate direct demand and trade diversion effects from induced price increases.

Three findings emerge. First, incidence varies across countries and products, highlighting the limitations of aggregate analyses. Second, incidence depends on both embedded emissions and product prices. Exporters supplying lower-priced products face larger ad valorem equivalent increases for the same emissions intensity. Third, direct demand effects dominate, while trade diversion becomes more important in concentrated product markets and when indirect emissions are included. The findings highlight the implications for industrial policy. Technological upgrading, stronger measurement, reporting and verification systems, domestic carbon pricing and cleaner electricity can reduce future liabilities and strengthen long-term competitiveness in EU markets.

Keywords: Climate Policy, Industrial Policy, European Union Carbon Border Adjustment Mechanism (EU CBAM), International Trade, Partial Equilibrium Modelling, Iron & Steel, Aluminium

JEL Codes: F13, F17, F18, L61, Q56

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Highlights:

- Highlights policy priorities for technological upgrading, electricity decarbonisation, domestic carbon pricing and MRV capacity.
- Develops a product-level partial equilibrium framework aligned with the institutional design of the EU CBAM.
- Illustrates that EU CBAM incidence depends on both embedded emissions and product prices.
- Finds heterogeneity in EU CBAM impacts across exporting countries, sectors and products.
- Demonstrates that direct demand effects dominate trade responses, while trade diversion depends on market structure.

1. Introduction

An important subject at the intersection of climate policy and international trade is the European Union's (EU's) Carbon Border Adjustment Mechanism (CBAM). The EU CBAM seeks to create a consistent application of carbon pricing across different countries by requiring imported goods to pay the same carbon cost on embedded greenhouse gas (GHG) emissions as goods produced within the EU.

The effects of the EU CBAM are imminent. On 1 January 2026, the EU CBAM moved to its definitive phase, implying that importers will be required to purchase and surrender EU CBAM certificates to cover the carbon cost of EU CBAM-covered imported goods. Currently the EU CBAM applies to EU imports of iron & steel, aluminium, cement, fertilisers, electricity, and hydrogen. Beyond these, the European Commission has identified several additional industries for further consideration, including pulp and paper, glass, ceramics, ferro-alloys (such as ferro-silicon and ferro-silicomanganese), alumina, aluminium hydroxide, and other non-ferrous metals (European Commission 2025g). Moreover, the Commission (2025e) has proposed an extension from 2028 to 180 downstream products containing significant steel or aluminium inputs. Future revisions may also broaden coverage to include downstream products linked to cement, fertilisers, and hydrogen value chains.

Except for cement and fertilisers, the EU CBAM presently covers only Scope 1 emissions, namely direct emissions generated from a firm's production processes. The European Commission (2025g) is expected to assess the extension of Scope 2 (indirect emissions associated with purchased electricity and heat) coverage across all sectors, with a possible legislative proposal anticipated in 2027.

The EU is not alone in the implementation or consideration of a border carbon adjustment (BCA). In 2023, the United Kingdom (UK) Government proposed a BCA covering aluminium, cement, fertiliser, hydrogen, iron, and steel sectors, with plans for this to be operational from 1 January 2027 (Department for Energy Security & Net Zero 2023). The Carbon Leakage Review appointed by the Australian government has recommended a BCA be introduced, initially covering cement, clinker and lime; hydrogen, ammonia and derivatives; iron & steel; and glass (DCCEEW 2025). Canada and Türkiye are also exploring the option of a BCA (Department of Finance Canada 2021, Boocker and Wessel 2025, Triplicane, et al. 2026).

Despite the environmental rationale, the EU CBAM has raised concerns, particularly within emerging economies. A growing body of literature highlights the potential for adverse distributional and competitiveness effects (Eicke et al. 2021, Perdana and Vielle 2022, Magacho et al. 2023, Majumder et al. 2024). Specifically, EU trading partners have expressed concern that the EU CBAM may constrain export opportunities and erode competitiveness in energy-intensive sectors. For example, Böhringer et al. (2018) argue that a BCA shifts part of the economic burden of developed-country climate policies onto emerging economies.

The implementation of the EU CBAM has elicited a wide range of empirical studies on the potential trade, carbon leakage mitigation, and socio-economic impacts (Böhringer et al. 2022, Fontagné and Schubert 2023, Zhong and Pei 2024). These differ by policy shock, modelling framework, level of aggregation, and outcomes studied. In this paper, this literature is extended using a multi-country product-level Partial Equilibrium (PE) model, as developed by the United Nations Conference on Trade and Development (UNCTAD) and the World Bank (Jammes and Olarreaga 2005). This model is used to study the trade and pricing impact of the EU CBAM on EU imports of iron & steel and aluminium products and contributes to the available literature along several dimensions.

The dominant empirical approach[2] models the EU CBAM within multi-sector, multi-country computable general equilibrium (CGE) frameworks, most commonly built on the Global Trade Analysis Project (GTAP) database (Zhong and Pei 2024, Maliszewska et al. 2025). Other approaches include Multi-Regional Input–Output (MRIO) frameworks (Magacho et al. 2023), new quantitative trade models (Mendoza et al. 2024), and structural gravity trade models (Korpar, et al. 2023, Mortha, et al. 2025). While these are empirically powerful in capturing cross-country diversion effects, within-country sectoral adjustments, and broader economic effects on employment, wages, production, and aggregate welfare, there are limitations. The sectoral aggregation in these studies often does not correspond with the more granular classification of EU CBAM industries. In addition, they rely on aggregated sector-level carbon intensity measures that mask substantial variation across products within sectors. It is thus difficult to translate aggregate results from available studies to the product-level liabilities and outcomes embedded in the design of the EU CBAM.

Further, the emissions-intensity factors in these studies are typically expressed relative to the value of trade - tonnes CO_2e per USD output (tCO_2e/USD) - and then applied directly to trade values. Under the EU CBAM, however, emissions are calculated on a physical basis as tonnes CO_2e per tonnes product (tCO_2e/t product) and applied to the volume of EU imports. Measuring emissions intensity relative to trade values introduces distortions where changes in

[2] For additional reviews of empirical methods, see: (Fontagné and Schubert 2023, Felbermayr, Peterson and Wanner 2025)

import prices mechanically alter the implied EU CBAM liability - even when the physical volume of imports, and so embedded emissions, remain unchanged.

Value-based emissions intensities also obscure differences in the ad valorem equivalent of the EU CBAM financial liability (liability as a percentage of the EU import price) across products of different quality and price. While the financial liability per tonne of imports will be equivalent for product varieties with the same emission factor, the proportionate increase in the EU import price will be higher for the lower-priced varieties compared to the higher priced varieties. The EU CBAM, therefore, disproportionately raises EU consumer prices of lower priced imported products, which are potentially more likely to be produced by emerging economies. This insight is lost when modelling emissions per USD value of trade.

The PE model in this paper resolves several of these limitations. The model is based on highly disaggregated product-level trade data classified at the 8-digit level of the EU Combined Nomenclature (CN). The trade data, therefore, maps precisely to the product classification used in EU customs declarations. To ensure precise emission factors, the model draws on detailed country- and product-level emission intensity values in tCO_2e/t product, provided by the EU's Joint Research Centre (JRC) (Vidovic et al. 2023). The simulations are also based on the volume of trade, thus aligning the measurement of emissions under the EU CBAM with the measurement of trade flows. The model therefore explicitly accounts for the country- and product-level heterogeneity in emission intensities that are frequently neglected in aggregate sectoral analyses.

The model is structured around capturing two trade effects: (a) direct import effects (demand effect) of the EU CBAM liability, based on the country-product specific emission intensities and product prices, and (b) indirect diversion effects, arising from differences in emission intensity across countries. For example, countries with relatively high emission intensities may experience a loss in competitiveness in the EU market relative to low-emission countries, resulting in additional declines in EU imports from trade diversion (over and above direct effects). To capture diversion effects, key sources of EU imports of iron & steel and aluminium are included[3].

The remainder of the paper is structured as follows: Section 2 provides an overview of the EU CBAM, Section 3 reviews the literature on potential impacts of the EU CBAM and the empirical methods used in this literature, Section 4 outlines the PE model used, Section 5

[3] 16 countries for each sector, plus the EU and a "Rest of World" (ROW) aggregate.

provides a brief overview of the trade flow data, Section 6 presents the modelling results, Section 7 provides policy recommendations and concludes.

2. The EU CBAM

The EU CBAM is a BCA that imposes charges based on the embedded GHG emissions of the product imported into the EU. The charge reflects the carbon price that would have been paid had these goods been produced under the EU Emissions Trading Scheme (ETS). The aim is to level the playing field between EU producers and foreign exporters and therefore limit carbon leakage, where emissions-intensive production relocates to countries with lower or no carbon pricing (Ward 2023). In addition to creating a level playing field, the EU anticipates that the EU CBAM will drive investment into energy-efficient technologies, cleaner energy sources, and industrial processes that reduce GHG emissions globally (Ramos 2024).

From 1 January 2026, the EU CBAM moved from a reporting-only transitional phase (2023–2025) to its definitive phase, requiring importers to register as authorised EU CBAM declarants, collect verified emissions data, and purchase and surrender EU CBAM certificates to cover the carbon cost of EU CBAM-covered imported goods (European Commission 2023) (Taxation and Customs Union 2025b)[4]. Initially, the EU CBAM applies to specific products within sectors selected due to their carbon-intensive nature and susceptibility to carbon leakage (Taxation and Customs Union 2023, Taxation and Customs Union 2025a). By 2034, the scope is expected to expand to include all product groups covered by the EU Emissions Trading System (ETS) and those at risk of carbon leakage (European Commission 2025g).

The effective liability imposed on importers of EU CBAM goods depends on several factors including the volume of imports, carbon prices of the EU Emissions Trading System (ETS), carbon costs paid by exporting countries, free allowances granted to EU producers, and the carbon dioxide emissions equivalent (CO_2e) intensity of production:

$$Liability_{fpjt} = \left[EF_{fpjt}\left(PC_t^{EU} - PC_{pjt}\right) - (B_pF_t)PC_t^{EU}\right] M_{fpjt} \quad (1)$$

Here, EF_{fpjt} is the embedded emissions intensity (tCO_2e/t product); M_{fpjt} is the volume of imports; PC_t^{EU} is the average weekly carbon price (per tonne) in the EU ETS; PC_{pjt} is the foreign carbon price (per tonne) paid in the origin country; and B_pF_t is the free allowance based on the product benchmark emission factor (B_p) and the free allowance factor (F_t). The subscripts *f*, *p*, *j*, and *t* denote firm, product, origin country and time, respectively.

4 Reporting declarants are not required to begin purchasing certificates for 2026 imports immediately but need to acquire certificates once there is clarity regarding total obligation - must be fulfilled by 31 August 2027 (European Commission 2025c, European Commission 2025d). This applies for EU imports in excess of the annual 50 metric tonne de minimis threshold.

The liability rises the higher the emission factor and EU carbon price. In addition, under Article 9 of the EU CBAM (European Commission 2025f), the liability explicitly allows for the subtraction of carbon prices paid on the product in the originating country. Lastly, free emission allowances reduce the liability but will be phased out in parallel with the phase-in of the EU CBAM between 2026 and 2034 (extension to 2037 proposed)[5] (European Commission 2026).

Critical to note is that behind the liability is the emission intensity EF_{fpjt}, which will vary by product and production process for each firm. Producers are required to follow specified measuring and monitoring methodologies, which must also be verified by independent, accredited third-party auditors (European Commission 2025a). In cases where verifiable product-level emission values are unavailable, country- and product-specific default values apply as per Commission Implementing Regulation (EU) 2025/2621 of 16 December 2025 (European Commission 2025b). These default values include annual mark-ups rising from 10% in 2026, to 20% in 2027, and 30% from 2028. In practical terms, EU imports that do not have verified plant-level emissions data will face progressively higher effective carbon liabilities.

Further, for complex goods, embedded emissions of relevant precursors – materials that are themselves EU CBAM-covered goods – need to be included in the calculation (Taxation and Customs Union 2025a, Taxation and Customs Union 2025b). For example, in cement production, the emissions from producing clinker, a key precursor, must be accounted for.

What this all means is that the GHG emissions embedded in products could differ significantly across firms that produce similar products.

3. Review of the literature – the potential impact of the EU CBAM

The EU CBAM has generated an expanding empirical literature assessing its economic, trade, and distributional impacts across countries and sectors. This section synthesises key empirical findings on the impacts of BCAs, followed by a review of the modelling approaches used in the literature. It then evaluates the limitations of these approaches, motivating the need for a product-level PE framework aligned with the institutional design of the EU CBAM.

Despite broad agreement that the EU CBAM will disproportionately affect emissions-intensive exporters, the magnitude and distribution of estimated impacts differ considerably

[5] Proposal to slow phase out of free EU ETS allowances for EU CBAM sectors, extending transition to 2037 and linking part of remaining free allocation to decarbonisation investments (European Commission 2026).

across studies owing to differences in both methodological approaches and the level of aggregation at which impacts are evaluated (Zhong and Pei 2024).

A meta-analysis of 25 multi-regional modelling studies by Branger and Quirion (2014) finds that the introduction of BCAs reduces average carbon leakage by approximately six percentage points globally, improves competitiveness in implementing countries' energy-intensive sectors, and partially mitigates output losses. More recent comparative-static CGE literature reaches similar conclusions. Böhringer et al. (2022), for example, show that while multi-region BCAs can reduce carbon leakage and improve cost-effectiveness of unilateral climate policy, their overall impact on carbon leakage remains limited due to partial sectoral coverage and implementation constraints.

Moreover, although BCAs can help restore competitiveness in implementing regions' energy-intensive sectors, they generate distributional effects by shifting welfare losses to exporting countries. For example, using a comparative-static multi-region and multi-sector CGE model, Böhringer et al. (2012) find that while BCA-type measures in the EU reduce carbon leakage (by approximately one-third relative to baseline), they do so at the cost of shifting economic burdens toward non-EU trading partners. Relatedly, Majumder et al. (2024) find that countries without domestic carbon pricing experience a decline in export sales and welfare. Although, impacts are concentrated in Emissions-Intensive, Trade-Exposed (EITE) sectors, and vary depending on trade exposure.

Further, CGE modelling finds that losses associated with asymmetric global impacts are concentrated in emerging economies. Xiaobei et al. (2022) employ a dynamic CGE model to capture adjustment paths over time, finding that a BCA-type policy implemented by the EU widens the gap between developed and emerging economies by reducing gross domestic product (GDP) and welfare in emerging economies, while constraining their capacity to invest in decarbonisation. Gu et al. (2023) implement a static multi-regional model and also find that an EU BCA-type measure reduces exports, output, and welfare in affected countries, including South Africa, China, India, and Brazil – all emerging economies.

Beyond CGE models, MRIO approaches emphasise the distribution of embodied emissions along global value chains. Magacho et al. (2023) use trade data and MRIO matrices to measure direct and indirect exposure in output, wages and employment, showing that the EU CBAM may have regressive effects because many emerging economies have limited capacity to shift from carbon-intensive sectors into greener activities. They find that in absolute terms, Russia, China, Türkiye and Ukraine are among the most exposed.

The African Climate Foundation and London School of Economics assess the EU CBAM using both CGE and New Trade Quantitative Model approaches (Aggad, et al. 2024). Under limited coverage, increasing the carbon price from EUR 40/tCO_2e to EUR 87/tCO_2e raises the estimated decline in Africa's exports to the EU from 1.32% to 2.84%, while the GDP effect worsens from −0.58% to −0.91%. The largest direct export losses are concentrated in aluminium, electricity, and iron & steel, while manufacturing, transport and services are also affected through input-output linkages. Under wider product coverage and removal of free EU ETS allowances, the GDP effect reaches −1.12%.

More recently, Chepeliev and van der Mensbrugghe (2026)[6] use a dynamic CGE model to examine the implications of the EU CBAM for South Africa and Mozambique. They find relatively modest economy-wide impacts but heterogeneous sectoral effects, with Mozambique experiencing large declines in aluminium output and exports, while South Africa records smaller reductions in iron & steel and aluminium. Their simulations incorporate projected EU ETS prices of EUR 69/tCO_2e in 2027, EUR 102/tCO_2e in 2030 and EUR 150/tCO_2e in 2035 and only include direct emissions.

Structural gravity models provide complementary evidence by modelling EU CBAM as a trade cost shock and tracing how bilateral trade flows adjust. Korpar et al. (2023) find that the proposed design of the EU CBAM has small aggregate effects: EU exports decline by only 0.04%, global emissions fall by 0.08%, and world exports decline by 0.12%. However, small aggregate effects mask sectoral reallocation – EITE sectors inside the EU expand, raising EU emissions by 0.24%, even as global emissions fall.

Mortha et al. (2025) extend the structural gravity literature by incorporating shipping emissions in addition to production emissions. Results show small welfare effects (regional changes below 1%), but larger trade and production effects in exposed sectors. Their simulations suggest export reductions ranging from 0.29% for metal products to 1.49% for iron & steel. They also find production rebounds in EU CBAM-implementing economies, with increases of 1.31% in non-ferrous metals and 5.24% in iron & steel, accompanied by higher EU production emissions. This reinforces the finding that the EU CBAM reduces foreign exports and may reduce global emissions, but partly by moving production into the EU rather than by inducing deep global decarbonisation.

[6] Differences in the results presented in this paper likely reflect the use of more recent trade data (2022–2023 rather than their use of a 2017 benchmark), product-level rather than GTAP sectoral aggregation, alternative emissions datasets, and differences in policy assumptions. This highlights the importance of modelling choices when assessing incidence.

New quantitative trade models reach similar conclusions. Mendoza et al. (2024) find that the EU CBAM improves the EU's terms of trade and generates small welfare gains for EU members. However, non-EU countries experience deteriorating terms of trade, small welfare losses, and marginal declines in real wages. Their model finds only marginal reductions in global GHG emissions, while EU emissions increase slightly.

More recently, emerging product-level PE evidence illustrates that aggregate estimates understate important heterogeneity[7]. Zhang et al. (2026) apply a product-level PE Global Simulation Model (GSIM) covering 13 countries[8], the EU and ROW aggregate. They include 222 steel products (aggregated to six categories) and consider 18 scenarios. They find that on average the EU CBAM modestly reduces global emissions in the iron & steel sector, while increasing EU welfare but imposing significant global welfare losses. Their results show that impacts differ across products due to variation in export values, emissions intensities, and dependence on the EU market. This supports the need for product-level analysis, since country and sectoral averages obscure the specific exporters and products facing the largest effective liabilities.

Several important limitations remain. A first key limitation across approaches is the trade-off between analytical scope and granularity. Most models are calibrated using GTAP databases (Chepeliev 2026). The key weakness of GTAP is that its sectoral aggregation does not correspond to the more granular product-level classification of EU CBAM sectors. To illustrate, in the GTAP database, fertiliser products are aggregated into a chemicals sector, cement into non-metallic minerals, and aluminium into non-ferrous metals.

The use of aggregate sector-level emission factors also distorts estimates of the carbon content of exports and misses important outcomes that vary at the product-level. For example, according to country-product calculations by Vidovic et al. (2023), direct plus indirect emission factors (tCO_2e/tonne output) for iron & steel products produced in South Africa vary from 0.74 to 7.47, with an average of 5.4. For aluminium, the total emission factor has a narrower (16 to 18) range, but a higher average (17.6) compared to iron & steel. Aggregate sector-level emission factors cannot account for this variation.

7 Other PE contributions (Mathieson and Maestad 2004, Demailly and Quiron 2008a, Demailly and Quiron 2008b, Monjon and Quirion 2011, Allevi et al. 2017, Xu and Hobbes 2021, Huang et al. 2021, Chu et al. 2024) introduce sector-specific modelling frameworks that incorporate firm or technology differences, but typically rely on average sectoral emissions intensities, limiting their ability to capture variation within industries.

8 EUs major trading partners include Brazil, China, India, Norway, Russia, Serbia, South Africa, South Korea, Switzerland, Türkiye, UK, Ukraine, and USA.

A further set of challenges relate to the calculation of embedded emissions. In almost all studies, embedded emissions are measured in CO_2e/USD, not per tonne of imports. Changes in international prices therefore distort estimates of embedded emissions in imports. For example, a rise in the USD price of EU CBAM products will artificially increase estimates of embedded emissions, even if there is no change in the production process. In contrast, as shown in equation (1), the EU CBAM liability is independent of product price, and there will be no change in the liability following price changes if import volumes (M_{fpjt}) do not change, holding emission factors and carbon prices constant.

A related limitation is that embedded emissions measured in terms of import value obscure the heterogeneity in the impact of the EU CBAM across products of different quality and price level. Using a simplified version of equation (1) that excludes the free allowances and the carbon taxes paid in the originating country, the ad valorem equivalent of the EU CBAM liability, can be expressed as the total liability divided by the value of imports as follows:

$$\tau_{fpjt}^{CBAM} = \frac{Liability_{fpjt}}{P_{fpjt} M_{fpjt}} = \frac{EF_{fpjt} . PC_t^{EU}}{P_{fpjt}} \quad (2)$$

Here, $P_{fpjt} M_{fpjt}$ is the value of imports, and P_{fpjt} is the import price per tonne. For a given emission factor and carbon price, the ad valorem equivalent of the EU CBAM liability (equivalent to the percentage increase in the import price inclusive of the liability) rises as the import price of the product falls. In contrast, emission factors based on value of trade impose constant ad valorem equivalents, that do not vary according to the initial import price[9]. An implication is that studies based on trade value-based emission factors may underestimate the distributional effects of the EU CBAM, in particular the effect on emerging economies that may produce lower quality, lower priced products produced using older more emission-intensive technologies.

4. Methodology – outlining the PE model

To address the limitations discussed above, this paper implements a multi-country product-level PE framework that is more consistent with the EU CBAM compliance mechanics. The model is based on the World Bank/UNCTAD PE model (SMART model), widely used to study the potential effects of free trade agreements (Laird and Yeats 1986, Jammes and Olarreaga 2005, Bacchetta et al. 2013).

[9] The ad valorem equivalent is simply $(CO_{2e}/EUR)_{pjt} \times PC_t^{EU}$, which does not vary according to import price.

The SMART model has several advantages for modelling EU CBAM impacts. Firstly, the approach explicitly accounts for the direct demand effects associated with changes in import prices, as well as trade diversion (indirect) effects arising from changes in the relative price of imports across different origins. Secondly, the model can be applied to disaggregated product-level data, allowing for variation in price effects across exporting countries and product lines.

The model simulates import changes in response to changes in import prices, such as those induced by the EU CBAM or tariffs. The change in EU import volumes of product p from country j (ΔM_{pjt}) is given by:

$$\Delta M_{pjt} = -\epsilon_p \frac{\Delta P_{pjt}}{P_{pjt}} M_{pjt} + \sum_{k \neq j} \left(\frac{M_{pjt} M_{pkt}}{M_{pjt} + M_{pkt}} \right) \left(\Delta \left(\frac{P_{pjt}}{P_{pkt}} \right) \Big/ \frac{P_{pjt}}{P_{pkt}} \right) \sigma_p \quad (3)$$

Here, ϵ_p (<0) denotes import demand elasticity and σ_p (<0) denotes the elasticity of substitution across exporters[10]. The first term on the right-hand side captures the direct demand effect on EU imports associated with higher import prices – as import prices rise, quantity demanded is expected to fall. The effect is larger the higher the percentage price increase and the elasticity of demand. The second term on the right-hand side captures the diversion effects. If country j experiences higher price increases than country k, it would be expected to see EU consumers redirect some of their imports away from j towards the relatively cheaper country k. The diversion effects depend on the substitutability of the products across sources, with larger effects associated with similar more homogenous products that have higher elasticities of substitution.

Substituting the percentage price changes from equation (2) into equation (3) yields the expression for import changes following implementation of the EU CBAM[11]:

$$\Delta M_{pjt} = -\epsilon_p \tau_{fpjt}^{CBAM} M_{pjt} + \sum_{k \neq j} \left(\frac{M_{pjt} M_{pkt}}{M_{pjt} + M_{pkt}} \right) \left(\tau_{fpjt}^{CBAM} - \tau_{fpkt}^{CBAM} \right) \sigma_p \quad (4)$$

This formulation allows for the estimation of EU CBAM-induced trade effects at a disaggregated level (by country and product), capturing variation in emissions intensity and trade structure that is not observable in more aggregated sectoral models.

[10] For the derivation of this relationship see Jammes & Olarreaga (2005).

[11] $\frac{\Delta P_{pjt}}{P_{pjt}} = \tau_{fpjt}^{CBAM}$. The change in relative prices, $\Delta \left(\frac{P_{pjt}}{P_{pkt}} \right) \Big/ \frac{P_{pjt}}{P_{pkt}}$, can be approximated by $\Delta \ln \left(\frac{P_{pjt}}{P_{pkt}} \right)$ which gives $\tau_{fpjt}^{CBAM} - \tau_{fpkt}^{CBAM}$.

As with all modelling approaches, there are several limitations. The model is 'partial' and static and therefore does not account for potentially important second round effects, including intersectoral linkage effects and across-product substitution and income effects. The simulated changes in trade from tariff adjustments are also based on existing trade flows, meaning that adjustments along the extensive margin (e.g. entry into new products or technologies) are not captured. Similarly, the deflection of existing exports to EU to alternative markets is not explicitly modelled. Lastly, final export responses will depend also on how the EU CBAM interacts with domestic carbon policies, including carbon pricing, regulatory processes, subsidies, and other industry incentives within the exporting country (Aggad, et al. 2024).

4.1. Model inputs

To implement the model, this paper makes several assumptions and draws on various sources of data. The results are sensitive to the choice of model parameters, including elasticities of export supply, import demand and substitution. Following previous studies, horizontal export supply in the exporting country is assumed, i.e. the export price remains fixed with the EU CBAM liability completely passed through to the EU importer. If exporters absorb some of the liability through lower prices, smaller EU import effects are expected.

The elasticity of substitution is assumed to be 1.5, as has been followed in most studies using this approach (Bacchetta et al. 2013, Jammes and Olarreaga 2005, Laird and Yeats 1986). Product-level (Harmonised System (HS) 6-digit level) import demand elasticities for EU countries are drawn from the SMART model available online from the World Integrated Trade Solution (WITS n.d.). Given large outlier values, the average import demand elasticities (ϵ_p<0) at the more aggregated HS 4-digit level are used. The median elasticity (absolute value) is 1.36 and ranges from 0.66 to 3.07, with an average across all products of 1.43. The median demand elasticity is slightly lower for aluminium products (1.19) compared to iron & steel products (1.41) and articles of iron & steel (1.37).

An advantage of this model in comparison with others is that it can estimate the EU CBAM-induced trade effects at a highly disaggregated product- and country-level. For this, EU import data at the CN 8-digit level for each trade partner are sourced from Eurostat (2026). The average import values for 2022-2023 are used to smooth the volatility of import values across years. The sample is restricted to only include products from the iron & steel and aluminium sectors that are covered by the EU CBAM (Taxation and Customs Union 2023, Taxation and Customs Union 2025a). Additional data for exports of HS 260112, which is poorly reported in Eurostat, are obtained for each country from UN Comtrade (2026)[12]. The Eurostat reported import data for this product is replaced with exports to the EU reported by each trade partner. Overall, the import data covers 478 iron & steel products and 64 aluminium products[13].

As discussed, aggregated emission factors are imprecise, as firm-level differences in technology, efficiency, and energy use can lead to significant variations. Ideally, plant- and product-level data would be used. As these are unavailable, product-level JRC estimates of direct and indirect emission factors of EU CBAM products for major exporters to the EU are used (Vidovic et al. 2023). The emission factors are constructed using publicly available data and follow the methodology and definitions of the EU CBAM monitoring and reporting rules[14]. The emission factors for iron & steel and aluminium cover 24 countries (16 countries and EU27 for each industry, with 10 overlapping). Jointly, the countries for which product-level trade and emissions data are available cover 84.5% of extra-EU imports of iron & steel products and 86.4% of aluminium products covered by the EU CBAM. The weighted average ROW emission factors provided in Vidovic et al. (2023) are applied to all other import sources.

A conservative carbon price of EUR 80/tCO_2e is assumed when calculating the EU CBAM liability. The liability is then converted into a tariff-equivalent (ad valorem equivalent) measure by dividing the resulting carbon cost per tonne by the product's import unit price from each source (Cadot et al. 2018). Unit values are obtained by dividing the EU reported import values by import quantities using data for 2022-2023. To deal with large outliers in unit values across countries, the unit values for each product are bounded to fall within the range of 0.25 times and 4 times the import-weighted average unit value (Silver 2010, Cadot, Ferrantino, et al. 2018, Eurostat 2024). Further, EU imports of iron & steel and aluminium from each country are excluded if the total is lower than the annual 50 metric tonne de minimis threshold (European Commission 2025d) required for the EU CBAM to apply[15].

Due to uncertainty around recognising third-country carbon pricing (Wildgrube et al. 2024), and measuring rebates or free allowances from carbon taxes currently applied in

[12] Russia is an exception as it does not have UN Comtrade (2026) reported trade data. Eurostat (2026) data for Russia is used

[13] CN 8 trade data more disaggregated than emissions dataset of Vidovic et al. (2023) - emission factors for 200 iron & steel and 27 aluminium CN codes. Greater product detail in the trade data allows all emission factors to be matched to trade flows.

[14] In December 2025, the European Commission released updated default direct emission factor values (European Commission 2025b) - indirect emission factors not provided. Values are higher than Vidovic et al. (2023) as they are intended to penalise firms that do not collect and verify data. Using these values would provide an upper-bound estimate of the trade effects.

[15] The thresholds apply to each trader, not country. The exclusion drops 3,152 out of 7,918 observations, but these only account for EUR 248.6 million of imports, or 0.07% total imports of iron & steel and aluminium products subject to the EU CBAM.

different countries, this deduction is excluded from the modelling in this paper[16]. The free emissions allowance is also excluded implying that the results are best interpreted as applying from 2037, after free allowances have been removed (European Commission 2026).

5. An overview of the trade flow data

An economy's exposure to the EU CBAM is influenced by, amongst other factors, the level, composition and dependence of exports to the EU of products covered by the EU CBAM[17]. To provide more insight, a descriptive analysis is presented for the countries included in the model. Table 1 presents summary statistics on value, share, number of products and concentration of EU imports for the iron & steel and aluminium sectors based on 2022–2023 averages. The data presents several insights. Imports are concentrated across countries, with intra-EU trade dominating total EU imports (71.3% share in iron & steel and 61.1% share in aluminium). China is the next largest source of iron & steel imports, accounting for approximately 5.2% of EU imports, followed by ROW (4.5%), Türkiye (3%), India (2.3%) and the UK (2.1%). The remaining countries account for less than 2% each. Extra-EU imports of aluminium products are more evenly distributed, with Norway the largest external source of imports (5.7%) followed by ROW (5.3%), China (5%), Türkiye (3.7%), Iceland (2.8%), Russia (2.4%) and Switzerland (2.3%).

The breadth and composition of CN 8-digit products exported to the EU also varies substantially across countries. On average (treating ROW as a single observation), each country exports 229 iron & steel products (out of a possible 478) and 36 aluminium products (out of a possible 64). However, there is cross-country heterogeneity. For iron & steel, Belarus exports only 58 products to the EU, whereas China exports 406, covering nearly the full product range. Similar differences are observed for aluminium: Mozambique, Iceland and Kazakhstan each export fewer than 10 products, while China and Türkiye export more than 60.

The product composition of EU imports from each country is also highly concentrated, although the dominant products differ across exporters. The final column of Table 1 reports the share of the top five iron & steel and aluminium products imported by the EU from each country (Appendix A provides the product-level breakdown). For iron & steel, the top five products account for between 23.5% of EU imports from India and 80.4% from South Africa.

[16] Limited modelling implications, as the net EU import price effect is expected to be similar whether an EU ETS equivalent carbon price is paid domestically or through the EU CBAM.

17 "Dependence" refers to the extent to which a country's exports rely on the EU as a market. This can be proxied by the share exports of a product directed to the EU (relative to total exports of the product to the world), the share of those exports in total exports to the EU, and the relative importance of the country as a supplier in total extra-EU imports. This captures exporter-side reliance on the EU market and the product's positioning within EU import demand.

Concentration is even greater for aluminium, also reflecting the smaller number of traded products, ranging from 48.4% for the ROW group to over 99% for Mozambique and Kazakhstan. By comparison, intra-EU trade is substantially more diversified, with the top five products accounting for only 19.0% of iron & steel imports and 37.3% of aluminium imports.

The dominant product also varies across stages of processing. For example, South Africa, Brazil, the ROW group and Ukraine primarily export agglomerated iron ores and concentrates (CN 26011200), whereas China, Switzerland and the United States of America (USA) primarily export processed articles of iron or steel (CN 73269098)[18].

Table 1: Summary statistics on EU imports of iron & steel and aluminium products by major source

	EU imports (EUR mil)	Share total EU imports (%)	Number of products	Share top 5 products (%)
Iron & steel				
Intra-EU	184,380	71.3	478	19.0
China	13,554	5.2	406	37.9
ROW	11,511	4.5	342	31.2
Türkiye	7,662	3.0	352	30.0
India	5,886	2.3	313	23.5
UK	5,325	2.1	374	28.2
Taiwan	4,660	1.8	172	28.4
South Korea	4,604	1.8	218	34.0
Russia	4,475	1.7	160	72.7
Ukraine	3,325	1.3	180	58.2
USA	2,615	1.0	223	40.0
Switzerland	2,525	1.0	252	31.4
Japan	2,154	0.8	177	51.3
Brazil	1,970	0.8	107	74.1
South Africa	1,805	0.7	61	80.4
Serbia	1,044	0.4	108	41.8
Norway	825	0.3	140	56.0
Belarus	153	0.1	58	53.0
Total EU	258,686	100	478	
Aluminium				
Intra-EU	54,075	61.1	64	37.3
Norway	5,084	5.7	34	83.8
ROW	4,680	5.3	60	48.4
China	4,390	5.0	63	58.1
Türkiye	3,310	3.7	61	54.1
Iceland	2,435	2.8	8	89.2
Russia	2,159	2.4	33	82.1
Switzerland	2,034	2.3	48	57.1
UAE	1,959	2.2	28	82.8
India	1,888	2.1	46	85.4
UK	1,545	1.7	54	54.4
Mozambique	1,497	1.7	8	99.8
Bahrain	1,099	1.2	24	79.5
USA	728	0.8	44	55.9
South Africa	648	0.7	23	89.7

[18] Evidence of concentration across countries within product lines also found. China and Türkiye, for example, together accounting for more than half of extra-EU imports of CN 7326 Other articles of iron & steel. Within aluminium, CN 7601 (unwrought aluminium) and CN 7606 (plates > 2mm thickness) have relatively diversified supply structures while CN 7604 (bars, rods and profiles) is more concentrated, with Türkiye alone accounting for almost half of extra-EU imports.

Egypt	432	0.5	29	64.0
Canada	265	0.3	13	94.5
Kazakhstan	257	0.3	5	100.0
Total EU	88,522	100	64	

Source: Authors' illustration using average EU import data for 2022-2023 reported by Eurostat (2026); CN 8-digit level.

Overall, the results suggest that EU CBAM trade flow exposure by structure and supplier concentration differs between and within product lines, even within the same sector. This reinforces the importance of analysing the policy at a disaggregated product and country level.

6. Modelling results

This section analyses the impact of the EU CBAM through two channels: (i) the EU import price effects, measured as financial adjustments and ad valorem equivalents, and (ii) the resulting simulated trade responses.

6.1. Import price effects of the EU CBAM

The EU CBAM affects trade primarily through its impact on EU import prices, which depend on the carbon cost applied to embedded emissions and initial price of the imported good – equation (2). This section decomposes sources of the price effects, focusing on how variations in embedded emissions and import prices translate into differences in the percentage impact of the EU CBAM on EU border prices (ad valorem equivalent) across products and countries.

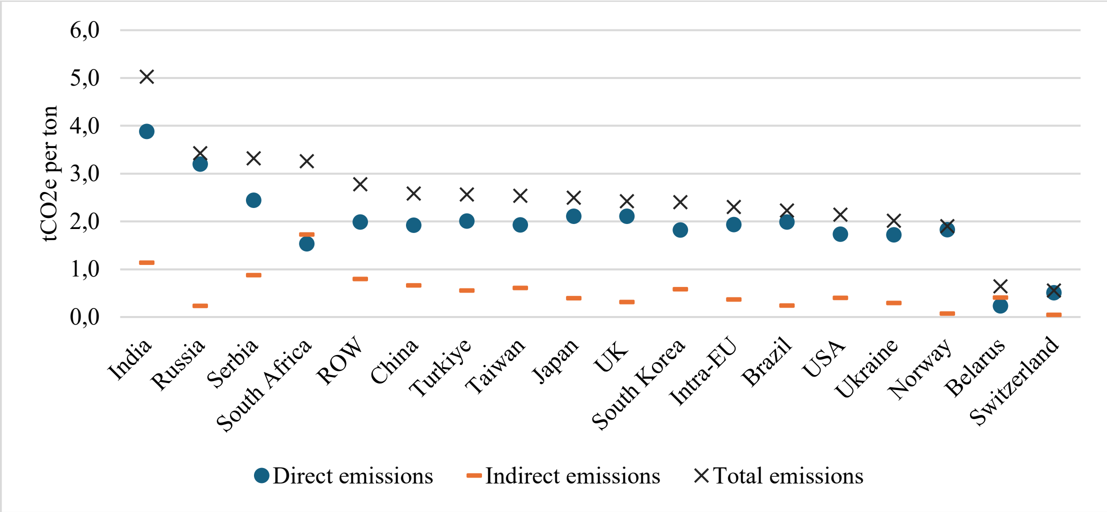
6.1.1. Emission factors

EU producers and importers of EU CBAM products pay the same carbon price. Thus, any differences in total EU CBAM certificate costs passed onto exporters[19] are attributable to differences in GHG emissions embedded in products. These emissions are country-, product-, and firm-specific, implying EU CBAM financial adjustment on imports and EU ETS cost for EU producers will differ significantly across countries, products, and producers.

To analyse further, Figures 1 and 2 compare the import-weighted average emission factors for the iron & steel and aluminium sectors across countries. This provides a measure of exposure to the EU CBAM as a function of both trade composition and emission factors. This provides several insights when it comes to the distribution of emission factors.

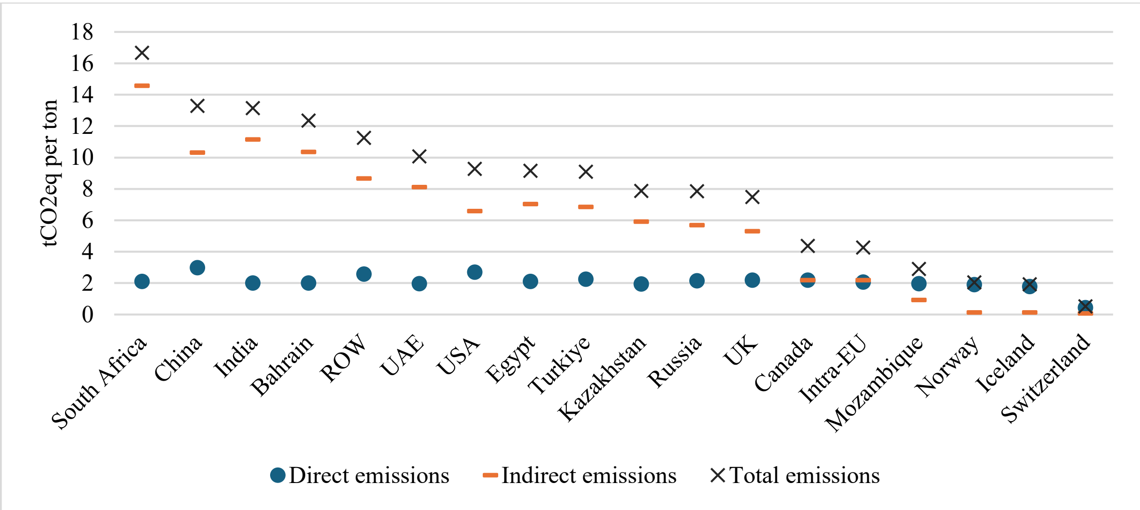
[19] Importers as reporting declarants are responsible for surrendering certificates, but the cost will be distributed based on the market power of participants throughout the value chain. Exporters that make up a small percentage of global supply, or that provide commodities, will bear a larger proportion of the EU CBAM cost than exporters of specialised goods or that are responsible for a large proportion of global supply (Dechezleprêtre et al. 2025).

Figure 1: Import-weighted average carbon emission factors for EU CBAM imports (iron & steel)



Source: Authors' calculations using data reported by Vidovic et al. (2023) and Eurostat (2026).

Figure 2: Import-weighted average carbon emission factors for EU CBAM imports (aluminium)



Source: Authors' calculations using data reported by Vidovic et al. (2023) and Eurostat (2026).

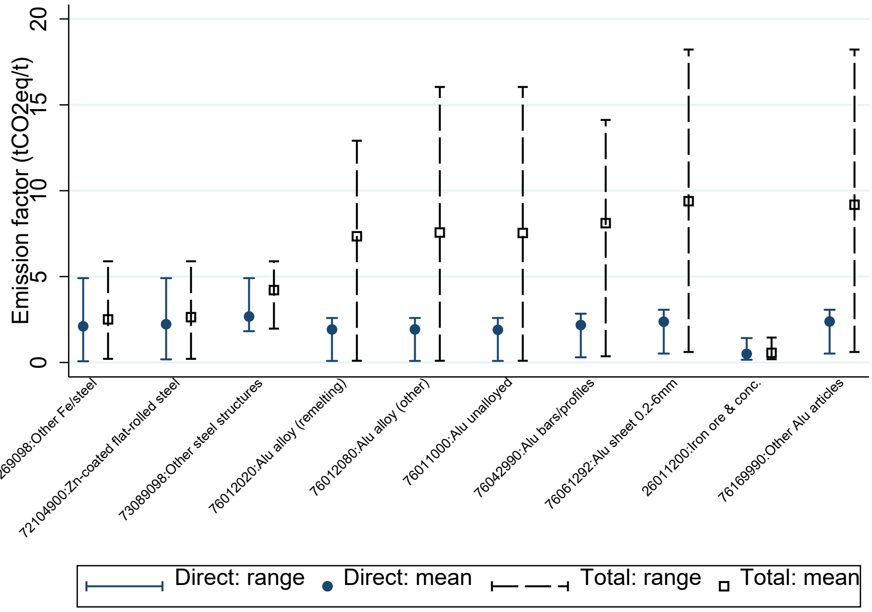
First, total emissions are generally higher for aluminium products than iron & steel products, but the main driver of the differences are the significantly higher indirect emissions for aluminium (5.9 tCO_2e/t output) compared to iron & steel (0.5 tCO_2e/t output). Iron & steel production generates a relatively large share of emissions directly through production processes, such as blast furnace or electric arc furnace (EAF) production. By contrast, the high indirect emissions associated with aluminium arise primarily from the electricity-intensive smelting process, while the energy requirements for downstream processing into sheets, bars and other products are lower.

Second, average total emissions (tCO_2e/t output) vary considerably across countries, ranging from 0.6 (Switzerland) to 5 (India) for iron & steel, and from 0.5 (Switzerland) to 16.7 (South Africa) for aluminium. However, the sources of this variation differ. Direct emissions are relatively similar across countries in the case of aluminium, with indirect emissions driving cross-country differences in total emissions. In contrast, with the exception of South Africa, indirect emissions are relatively similar for iron & steel with direct emissions the main source of cross-country differences in total emissions. The high indirect emissions for South Africa arise from the extensive use in the country of coal-fired power plants to generate electricity.

Third, middle-income economies including South Africa, India, China, and Russia, have the highest emission factors. By contrast, advanced economies, such as Switzerland, Norway, and Iceland, tend to exhibit lower emission factors. This pattern suggests that EU CBAM incidence is not evenly distributed across countries at different stages of economic development. There are exceptions – the electricity used in aluminium production in Mozambique comes primarily from hydropower (Cahora Bassa Dam on the Zambezi River).

The country-level aggregates, however, hide substantial variation in emission factors between and within products. To illustrate this variation, Figure 3 plots the cross-country range and mean values of the direct and total emission factors for the top 10 iron & steel or aluminium products imported into the EU (by import value). Together, these products make up 24.3% of EU imports from the two sectors.

Figure 3: Direct vs Total emission factors: top 10 products by EU import value



Source: Authors' calculations using data reported by Vidovic et al. (2023) and Eurostat (2026). "Alu" denotes aluminium, "Fe" denotes iron, "Zn" denotes zinc. The order from left to right is according to total value of EU imports.

Figure 3 reveals large differences in mean emission factors between products, with indirect emissions noticeably increasing total emissions of aluminium products relative to iron & steel products. The vertical range plots in Figure 3 also illustrate wide variation in emission factors across countries within each product. By including indirect emissions, the cross-country distribution of total emission factors is widened, particularly in aluminium[20].

Several implications for the modelling of the EU CBAM follow. Emission factors vary widely across countries and across products, depending crucially on whether indirect emissions are included. Thus, suppliers competing within the same EU market segment can exhibit substantially different carbon intensities despite producing similar products. The aggregation of industries and emission factors, as in CGE models, obscures this variation.

Differences in indirect emission factors are driven by sector-specific technologies and energy systems - e.g., coal-fired power in South Africa and India versus renewable energy in Iceland and Norway. Consequently, when including indirect emissions, the incidence of the EU CBAM will reflect structural differences in electricity generation and systems. These patterns are relevant given the planned future inclusion of indirect emissions for all sectors under the EU CBAM (European Commission 2025g). While this inclusion may improve environmental coverage, it also introduces greater variation in carbon liabilities across EU trade partners.

Lastly, it is important to note that the analysis above is conducted at the country-product level, but in practice additional heterogeneity exists across firms. This implies that actual EU CBAM liabilities may vary even more than suggested here.

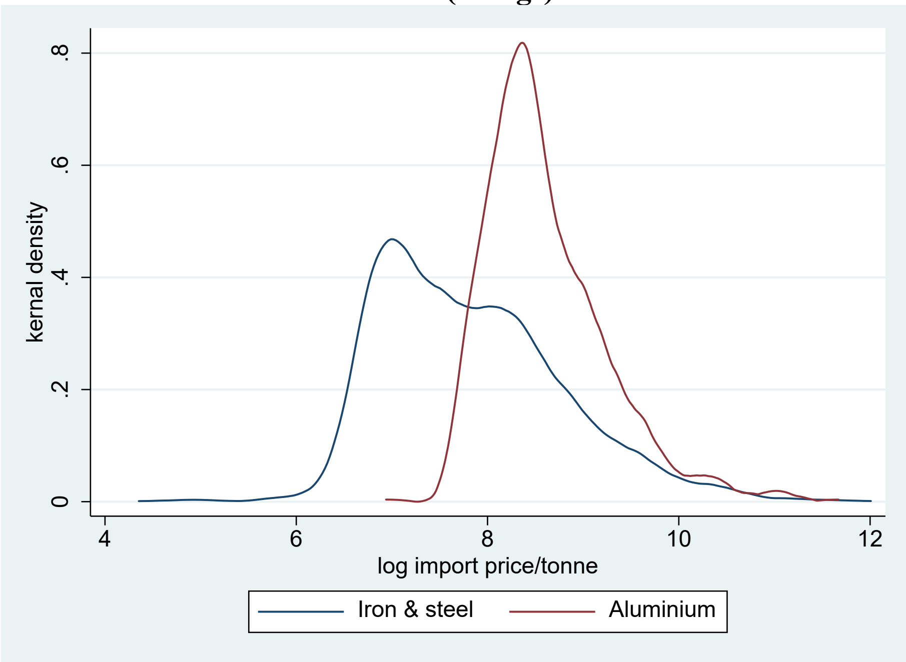
6.1.2. Import prices

While higher emissions intensities increase the financial liability for each tonne of imports, their impact on consumer behaviour depends critically on how they affect import prices. As shown in equation (2), the percentage increase in price in turn depends on the EU CBAM liability relative to the initial import price. Consequently, products with identical embedded emissions can face different percentage price increases, with larger increases for low priced imported products. This introduces a structural asymmetry that is not linked to environmental performance alone and largely overlooked in available empirical studies.

[20] For example, the country-level emission factors for the highest import value product, other iron & steel products (CN 73269098), range from 0.07 to 5.89 tCO_2e/t output. The inclusion of indirect emissions expands this range, but only marginally. Unalloyed aluminium (CN 76011000) has a slightly narrower range of direct emissions (0.09 to 2.59 tCO_2e/t output), but this rises to a range of 0.1 to 16.04 tCO_2e/t output once indirect emissions are included. Total emission factors thus exhibit greater cross-country heterogeneity for aluminium products.

The relevance is illustrated in Figure 4, which presents a kernel density distribution of import unit values - in logarithms (logs) - across countries and products for the iron & steel and aluminium sectors. The unit values are calculated as EU import value divided by quantity (in tonnes). The price per tonne of aluminium products is on average higher than iron & steel products, but the variation in prices is very large[21]. This variation far exceeds that of emission factors, indicating that price differences will be the primary determinant of variations in the import price effect of the EU CBAM.

Figure 4: Kernel density distribution of import prices across products and countries by sector (in logs)

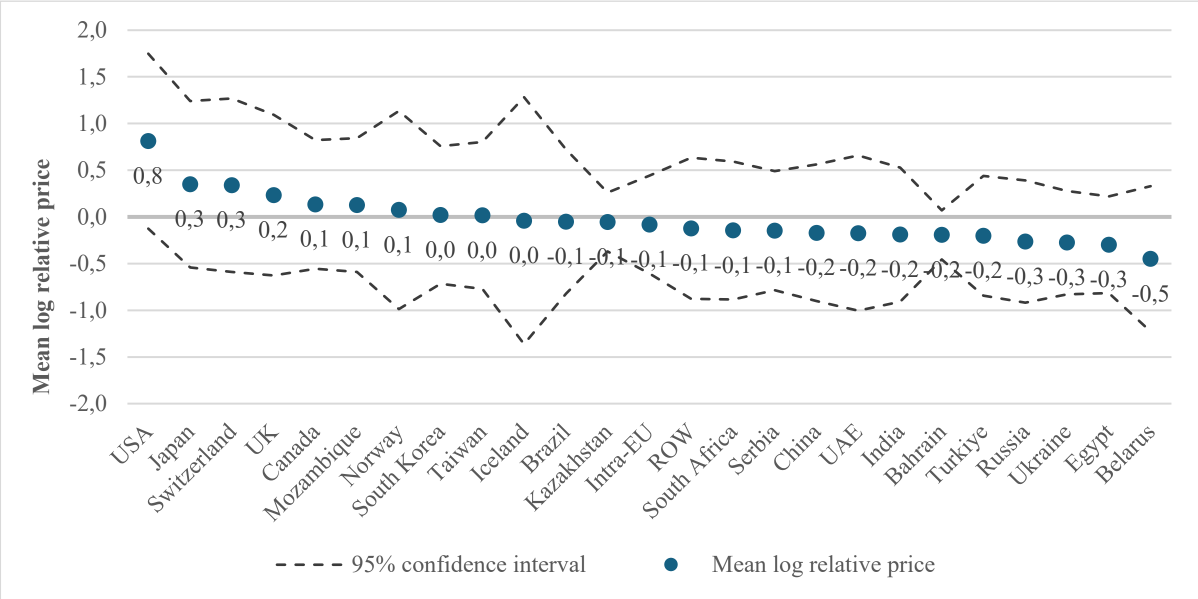


Source: Authors' calculations using data reported by Vidovic et al. (2023) and Eurostat (2026).

One reason for these import price differences is wide cross-country variation in the quality of product varieties, even within narrowly defined product categories. These price differences – commonly interpreted as reflecting quality, following Schott (2004) – also correspond broadly with exporters' level of development, as measured by GDP per capita (World Bank 2024). To illustrate this, each price is first expressed as its log deviation from the product-level geometric mean price of all countries that export the product to the EU. Figure 5 then plots the average of these relative prices across products for each country, using the full sample of aluminium and iron & steel products. Countries are ranked from highest to lowest according to this value.

[21] For example, the 90th percentile price of iron & steel products (EUR 8,896/t) is 10.4 times the 10th percentile price (EUR 866/t). The 90th/10th ratio for aluminium products is 4.6 (EUR 12,711/t by EUR 2,747/t).

Figure 5: Mean log relative prices and 95% confidence intervals by country for combined iron & steel and aluminium sectors



Source: Authors' calculations using data reported by Vidovic et al. (2023) and Eurostat (2026). Mean log relative price denotes the cross-product average for each country of the log of the EU import price relative to the geometric average EU import price of the product.

High-income economies such as the USA, Japan, Switzerland, UK, and Canada rank near the top of the price distribution, exporting higher-priced varieties than middle-income countries such as Belarus, Egypt, Türkiye, India and China[22]. On average EU import prices of US products are 125% higher than the mean import price. Those from Egypt are on average 26% lower than the mean import price. Exceptions include Mozambique that exports relatively high-priced varieties of aluminium products.

Also included in Figure 5 are the upper and lower bounds of the 95% confidence interval for each country. The confidence intervals are wide, reflecting substantial variation in relative prices within each country. All countries export combinations of products to the EU with prices higher as well as lower than the average. This variation in prices across products and countries provides strong support for the use of disaggregated product-by-country-level data when modelling the impact of the EU CBAM.

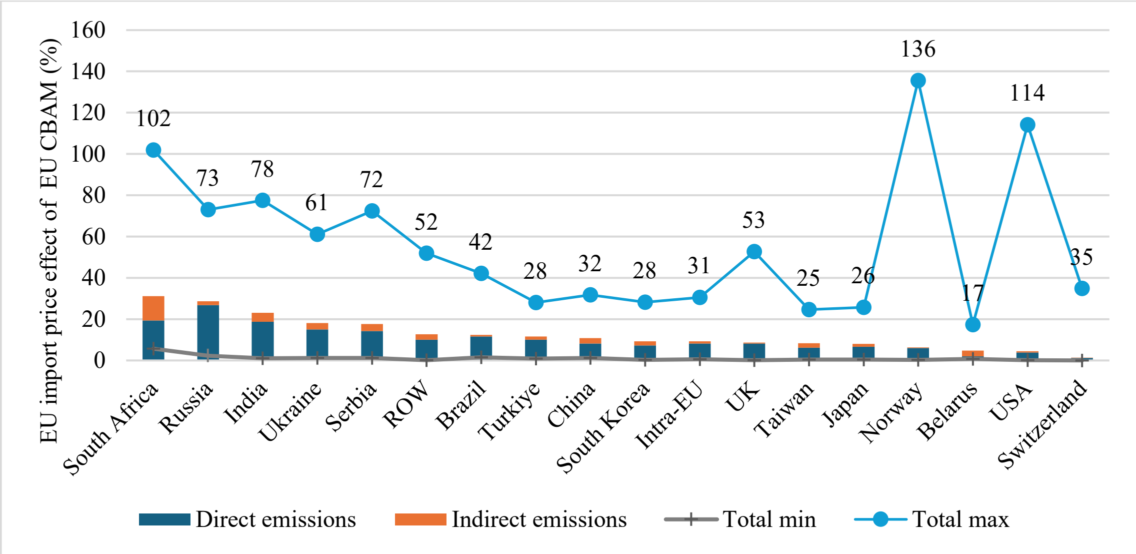
6.1.3. Ad valorem equivalent price effects of the EU CBAM

To close off the background analysis, this section combines the information on emission factors and import prices to calculate the percentage increase in EU CBAM-inclusive EU import prices

[22] Econometric estimates corroborate this finding. Simple ordinary least square estimates of EU import prices on GDP per capita (both in logs) and HS 8-digit level fixed effects yield a positive and significant (at 1% level) elasticity of 0.21. The results imply that a 10% increase in GDP per capita is associated with a 2.1% higher import price on average.

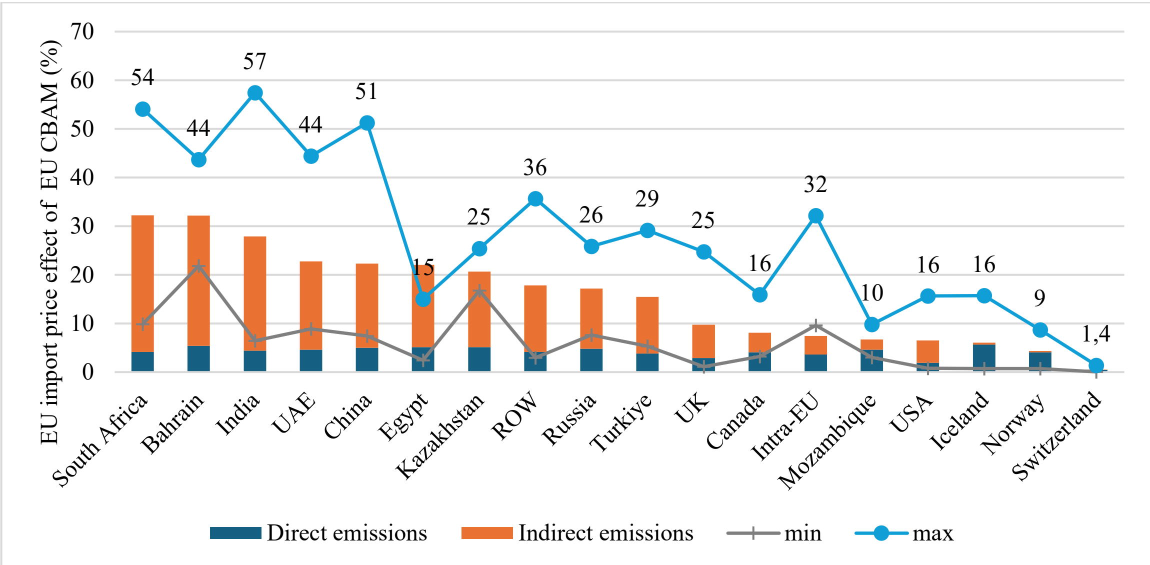
associated with a EUR 80/tCO_2e carbon price, as per equation (2)[23]. Figures 6 and 7 present the mean, maximum and minimum estimated percentage increases in EU import prices of iron & steel and aluminium products, respectively, covered by the EU CBAM for each country. The mean price increase is also decomposed into contributions from direct and indirect emissions.

Figure 6: Mean, maximum and minimum EU import price effect by country for iron & steel sector



Source: Authors' calculations using data reported by Vidovic et al. (2023) and Eurostat (2026).

Figure 7: Mean, maximum and minimum EU import price effect by country for aluminium sector



Source: Authors' calculations using data reported by Vidovic et al. (2023) and Eurostat (2026).

The results corroborate the prior findings. The inclusion of indirect emissions raises the EU price effect of the EU CBAM by a considerable amount, particularly for aluminium products.

[23] A higher carbon price will increase the EU CBAM-inclusive EU import prices, but will affect all products uniformly, and therefore not affect the relative rankings across products and countries.

On average, EU import prices of iron & steel products from all sources increase by 9.7% when including direct emissions but rises to 11.7% when including indirect carbon emissions. For aluminium, the average product price increases by 3.8% when including only direct carbon emissions, and 15.2% when also including indirect emissions.

The price effects also vary substantially across countries and products. South Africa experiences the highest average price increases for products in both the aluminium (32% with total emissions) and iron & steel (31% with total emissions) sectors, but largely because of very high indirect emissions. The EU price effects do not vary much across origins for aluminium products when only direct emissions are considered. Switzerland experiences the lowest EU average import price increases for both sectors, primarily because of its combination of low emission factors and high product prices.

The variation in EU price increases across products is enormous. For South Africa, the prices of iron & steel products increase by between 5.7% and 102% if both direct and indirect emissions are included. The range for Türkiye, China, South Korea, Taiwan and Japan is much narrower, with EU import price increases below 30% for all iron & steel products. For Norway, high direct emissions combined with low EU import prices for pig iron (HS 72011) drive the maximum price increase to 136%, whereas for the USA, the maximum 114% EU price increase is driven by the very low import price of iron ores & concentrate (HS 260112). The range of price increases for aluminium products is lower than for iron & steel, with imports of non-rectangular sheets of thickness exceeding 0.2mm (HS 760691) from India facing the highest EU import price increases (57%). The increase in price of this product falls to 9.4% if direct emissions are only considered.

Importantly, these results demonstrate that the import price incidence of the EU CBAM is shaped not only by carbon intensity, but also by the structure of international prices within product markets. Firms that export low priced products with high carbon emissions would face amplified price increases in the EU market, and consequently relatively sharp reductions in EU import demand. These results suggest that emissions intensity alone provides an incomplete picture of EU CBAM incidence. Instead, given that the import price effect of the EU CBAM depends on both embedded direct emissions and initial import price levels, the incidence is determined by their interaction.

6.2. Simulation results (SMART model)

The following presents a comparison of the simulated impact of the EU CBAM on EU imports from its trade partners. Two simulations are presented: (a) A direct emissions simulation where the EU carbon price is only applied to direct emissions, as is currently the policy, and (b) a total emissions simulation where the carbon price is applied to direct and indirect emissions.

6.2.1. Impact on EU imports

The simulated impacts on EU imports for the two simulations are presented in Table 2 for the iron & steel sector and Table 3 for the aluminium sector. On aggregate, EU imports from all sources, including within the EU, fall by 15% for iron & steel products covered by the EU CBAM and 5% for aluminium products covered by the EU CBAM when only direct emissions are covered in the policy. These declines in imports rise to 17.2% for iron & steel and 13.1% for aluminium once indirect emissions are also included. However, the percentage change in EU imports varies across supplier countries.

To isolate the sources of these trade flow changes, and how they vary across countries, Tables 2 and 3 decompose the percentage change in EU imports from each trade partner into the estimated demand effect and estimated diversion effect (Appendix B provides the accompanying Figure). Looking first at the iron & steel sector (Table 2), all trade partners in the model experience negative direct demand effects in response to higher EU import prices. For iron & steel, the largest reductions occur for Russia, Ukraine, South Africa and India, where the direct demand effects range between declines of 32% and 68% when including direct emissions and declines of 38% to 71% when also including indirect emissions.

Estimated diversion effects are generally smaller in magnitude, although they partially offset losses for some countries, including the UK, Norway, the USA, Switzerland and Belarus. For Belarus and Switzerland, positive diversion effects outweigh negative demand effects, resulting in net increases in EU imports from these origins. For the most affected countries, the diversion effects amplify the fall in EU demand resulting in declines in total EU imports of more than 48% (56% when including indirect emissions) for India, Ukraine, South Africa and Russia. Overall, however, the EU CBAM primarily reduces imports through lower EU demand associated with higher effective import prices, rather than through substitution across suppliers.

Table 2: Simulated impact of the EU CBAM on EU imports of iron & steel products by major source country

		Direct emissions only simulation				Direct & indirect emissions simulation			
	Initial imports (EUR mil)	Change imports (EUR mil)	Demand effect (%)	Diversion effect (%)	Comb. effect (%)	Change imports (EUR mil)	Demand effect (%)	Diversion effect (%)	Comb. effect (%)
Russia	3924	-3251	-68.2	-14.7	-82.8	-3353	-71.2	-14.3	-85.4
South Africa	1805	-866	-40.3	-7.7	-48.0	-1377	-62.8	-13.5	-76.3
Ukraine	3321	-1781	-44.4	-9.2	-53.6	-1939	-48.6	-9.7	-58.4
India	5886	-2808	-32.3	-15.4	-47.7	-3307	-37.9	-18.3	-56.2
Serbia	1044	-279	-22.3	-4.4	-26.7	-373	-27.9	-7.8	-35.7
ROW	11279	-2252	-19.8	-0.2	-20.0	-2953	-24.2	-2.0	-26.2

Brazil	1970	-484	-27.7	3.1	-24.6	-475	-28.6	4.5	-24.1
Japan	2154	-385	-17.8	-0.1	-17.9	-437	-19.8	-0.4	-20.3
Türkiye	7662	-1255	-15.5	-0.8	-16.4	-1517	-18.5	-1.3	-19.8
South Korea	4604	-608	-15.0	1.8	-13.2	-790	-18.0	0.9	-17.2
Taiwan	4660	-548	-11.9	0.1	-11.8	-699	-14.2	-0.8	-15.0
China	13554	-1368	-9.7	-0.3	-10.1	-1961	-12.7	-1.7	-14.5
Intra-EU	184128	-22152	-12.9	0.8	-12.0	-24502	-14.5	1.2	-13.3
UK	5323	-595	-11.9	0.7	-11.2	-613	-13.1	1.5	-11.5
Norway	825	-62	-14.4	6.9	-7.5	-45	-15.1	9.7	-5.5
USA	2443	-41	-5.3	3.6	-1.7	-36	-5.6	4.1	-1.5
Switzerland	2525	149	-1.7	7.6	5.9	181	-1.9	9.0	7.2
Belarus	153	24	-2.2	17.9	15.7	13	-6.6	15.3	8.7
Total	257261	-38563	-15.0	0.0	-15.0	-44182	-17.2	0.0	-17.2

Notes: Model results based on carbon price of 80 EUR/tCO₂e.

Table 3 demonstrates that the estimated impacts for aluminium (direct emissions only) are smaller than for iron & steel, with most countries experiencing net declines in EU imports of between approximately 4% and 10%. The range of estimated losses across countries is also narrower, reflecting direct emissions with more similar intensities across aluminium exporters and lower implied price adjustments. However, this outcome changes once indirect emissions are included. South Africa experiences the largest decline in EU imports (75%), followed by Bahrain and India (64% each) and then USA (50%). Russia, Kazakhstan, China and Türkiye experience additional declines in EU imports of more than 20 percentage points.

Table 3: Simulated impact of the EU CBAM on EU imports of aluminium products by major source country

		Direct emissions only simulation				Direct & indirect emissions simulation			
	Initial imports (EUR mil)	Change imports (EUR mil)	Demand effect (%)	Diversion effect (%)	Comb. effect (%)	Change imports (EUR mil)	Demand effect (%)	Diversion effect (%)	Comb. effect (%)
South Africa	648	-45	-6.8	-0.1	-6.9	-485	-45.7	-29.1	-74.9
Bahrain	1099	-87	-7.4	-0.5	-7.9	-703	-40.2	-23.8	-64.0
India	1888	-141	-7.4	-0.1	-7.5	-1202	-42.0	-21.7	-63.7
UAE	1959	-149	-7.4	-0.2	-7.6	-988	-34.3	-16.2	-50.4
Egypt	432	-35	-6.9	-1.1	-8.0	-179	-27.6	-13.8	-41.4
ROW	4680	-349	-6.4	-1.1	-7.5	-1786	-25.5	-12.6	-38.2
Russia	2159	-200	-8.3	-1.0	-9.3	-777	-27.9	-8.1	-36.0
Kazakhstan	257	-20	-8.1	0.2	-7.9	-88	-30.0	-4.3	-34.2
China	4390	-298	-4.9	-1.9	-6.8	-1490	-20.1	-13.8	-33.9
Türkiye	3310	-150	-4.2	-0.3	-4.5	-811	-16.1	-8.4	-24.5
UK	1545	-71	-4.7	0.1	-4.6	-301	-15.4	-4.1	-19.5
Canada	265	-28	-9.3	-1.4	-10.7	-29	-17.9	7.1	-10.9
Intra-EU	54075	-2411	-4.5	0.1	-4.5	-3374	-9.2	3.0	-6.2
USA	728	4	-1.7	2.2	0.5	-16	-5.6	3.5	-2.1
Mozambique	1497	-118	-7.9	0.0	-7.9	30	-11.5	13.5	2.0
Norway	5084	-303	-6.3	0.3	-6.0	179	-6.7	10.2	3.5
Iceland	2435	-138	-6.6	0.9	-5.7	182	-7.0	14.5	7.5
Switzerland	2034	75	-0.6	4.3	3.7	222	-0.7	11.7	10.9
Total	88484	-4465	-5.0	0.0	-5.0	-11615	-13.1	0.0	-13.1

Notes: Model results based on carbon price of 80 EUR/tCO₂e.

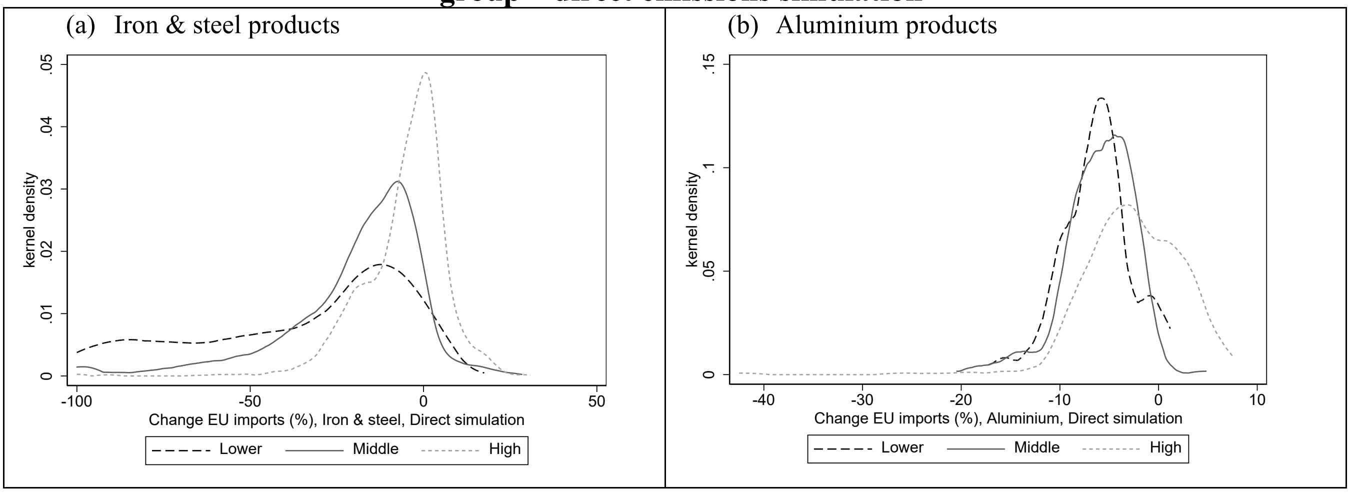
Much like iron & steel, when including direct emissions only, estimated diversion effects remain relatively modest in comparison to estimated direct demand effects. Switzerland and the USA experience positive net effects due to relatively strong diversion gains, while Norway, Iceland, Kazakhstan, intra-EU and UK also benefit from small positive diversion effects that partially offset negative demand effects. All other countries/regions in the sample experience diversion effects that amplify direct demand losses.

The inclusion of indirect emissions leads to higher estimated losses in EU imports for most countries, with diversion effects playing an increasingly important role. For example, the diversion effects after including indirect emissions contribute over 32% of the total decline in EU imports of aluminium products from South Africa, Bahrain, India, the United Arab Emirates (UAE), Egypt, China and Türkiye, compared to an average share of 9% when only direct emissions are considered. The countries that benefit from diversion effects are Mozambique, Norway, Iceland and Switzerland (net increases in EU imports of 2% to 11%).

6.2.2. Heterogeneity in impact across countries and products

As can be expected, there is substantial heterogeneity in the impact at the country-product level. Figure 8 presents distributions of the percentage change in EU import value at the product level by exporters grouped into lower, middle- and high-income categories, using the direct emissions simulation.

Figure 8: Distribution of simulated changes in EU import value by exporter income group – direct emissions simulation



Notes: Model results for the direct emissions simulation based on carbon price of 80 EUR/tCO_2e. Lower = Mozambique, India, Egypt; Middle = Ukraine, South Africa, Belarus, Brazil, China, Serbia, Kazakhstan, Russia, Türkiye; High = Bahrain, Japan, South Korea, EU, UAE, UK, Canada, USA, Iceland, Norway, Switzerland. Countries are classified as falling in the middle category if their GDP per capita in 2024 falls between USD 4,500 and USD 16,000. This classification differs from the World Bank income classification, where countries with Gross National Incomes per capita above USD 14,005 in 2024 are classified as high-income.

While considerable heterogeneity exists across products and exporters, the largest import declines are generally concentrated among lower- and middle-income economies. Higher-income exporters, by contrast, tend to experience smaller losses and, in some cases, gains through trade diversion[24]. This can also be seen by the rightward orientation of the distribution function for the higher-income group compared to the other groups. However, Figure 8 also reveals considerable overlap across the distributions, reflecting product and country heterogeneity in the change in EU imports following implementation of the EU CBAM.

Similar heterogeneity in outcomes is found for aluminium products, although the distribution of the change in EU import values is much narrower. EU imports of the median aluminium product-country observation in the lower-income group fall by 6%, compared to 5.4% for the middle-income group and 2.8% for the higher-income group. As shown in Appendix C, the inclusion of indirect emissions in the simulations widens the distribution of import changes and amplifies the apparent bias against countries in the lower- and middle-income groupings.

These patterns do not imply that GDP per capita itself determines EU CBAM incidence. Rather, income levels[25] are correlated with factors such as production technologies, electricity systems (in the case of indirect emissions), emissions intensities and export unit values. Higher-income economies appear to export higher-value products and exhibit lower embedded emissions, reducing the effective ad valorem equivalent of the EU CBAM. By contrast, several emerging economies combine more emissions-intensive production with lower product prices, resulting in larger price increases and export losses. This suggests that the distributional effects of the EU CBAM may extend beyond environmental performance alone, potentially imposing larger adjustment costs on some emerging economies.

7. Conclusion and policy implications

Broadly, the paper demonstrates that product- and country-level heterogeneity matters. Aggregate sector-level analyses obscure important differences in emissions intensities, prices and market structure, that ultimately determine the EU CBAM incidence. As the EU CBAM expands to downstream products, additional sectors and potentially indirect emissions, incorporating heterogeneity will become important for understanding trade, competitiveness and environmental consequences.

[24] For example, the decline in EU imports for the median iron & steel item in the lower-income group is 23.4%, compared to 14.7% for the middle-income group and 3.1% for the higher-income group.

[25] An alternative proposal is an international carbon price floor with differentiated minimum prices across country-level income groups, reducing the need for unilateral BCAs while recognising differences in development levels (Parry et al., 2021).

Using a product-level PE framework aligned with the institutional design of the EU CBAM, the analysis shows that trade impacts vary substantrially across countries and products, and that the inclusion of indirect emissions would considerably increase these differences.

These findings have several implications for both the design of the EU CBAM and the policy response of exporting countries. While the EU CBAM is unlikely to transform production patterns through market incentives alone, it strengthens the economic case for decarbonisation by increasing the returns to emissions reductions. Complementary national policies remain necessary to overcome investment, coordination and financing constraints.

1. Industrial policy should facilitate firm adjustment, not simply leave firms to absorb higher costs: The results suggest that the EU CBAM should be viewed not only as a trade measure but also as an innovation signal. Firms can reduce liabilities by lowering emissions intensity through cleaner production technologies or by upgrading towards higher-value product varieties. However, for many emissions-intensive industries these investments are capital intensive and unlikely to be justified by the EU CBAM alone. Therefore, governments have an important role through targeted industrial policy. Examples include carbon tax revenue recycling, investment tax credits, concessional finance or recapitalisation funds and research and development (R&D) incentives. In the iron & steel sector, for example, policies facilitating a transition towards lower-emission production routes such as scrap-based EAF production can reduce embedded emissions and therefore future EU CBAM liabilities. Similarly, in the aluminium sector, policies supporting investment in modern smelter technologies can reduce emissions associated with the anode effect, where perfluorocarbon (PFC) gases with very high global warming potential are generated.

2. National energy policy increasingly becomes trade competitiveness policy: The simulations demonstrate that extending the EU CBAM to indirect emissions changes the policy challenge. For many exporters, future EU CBAM liabilities increasingly depend on the carbon intensity of national electricity systems rather than solely on firm-level production decisions. This reinforces the importance of electricity-sector decarbonisation as both a climate and trade competitiveness strategy, especially if BCAs become widespread internationally. Governments therefore have a central role in expanding low-carbon electricity generation, modernising electricity networks, improving grid reliability, and creating regulatory frameworks that enable firms to procure renewable electricity through mechanisms such as power purchase agreements (PPAs). While the EU CBAM should not determine national energy policy, it reinforces the economic rationale for these reforms by increasing the trade competitiveness benefits of electricity-sector decarbonisation, particularly if similar BCAs are adopted elsewhere.

3. Carbon pricing should keep revenues at home: The results reinforce the importance of domestic carbon pricing. Countries with explicit carbon pricing systems that satisfy EU requirements can retain carbon revenues domestically rather than transferring them abroad through EU CBAM certificate purchases. Designing domestic carbon pricing systems that are compatible with EU recognition therefore has both fiscal and competitiveness benefits. Equally important is how revenues are used. Where possible, recycling revenues into decarbonisation and technology upgrading can strengthen firms' ability to reduce future liabilities.

4. Capacity building matters: Finally, effective implementation depends on measurement, reporting and verification (MRV) systems[26]. Firms unable to report verified emissions face conservative default values that increase liabilities. Investment in MRV systems, accredited verification, and technical assistance (particularly smaller exporters) could improve both compliance and the perceived legitimacy of the EU CBAM.

[26] Do (2025) proposes a "CBAM-Plus" framework that combines BCAs with revenue recycling, technology transfer and MRV capacity building to better align climate objectives with development outcomes.

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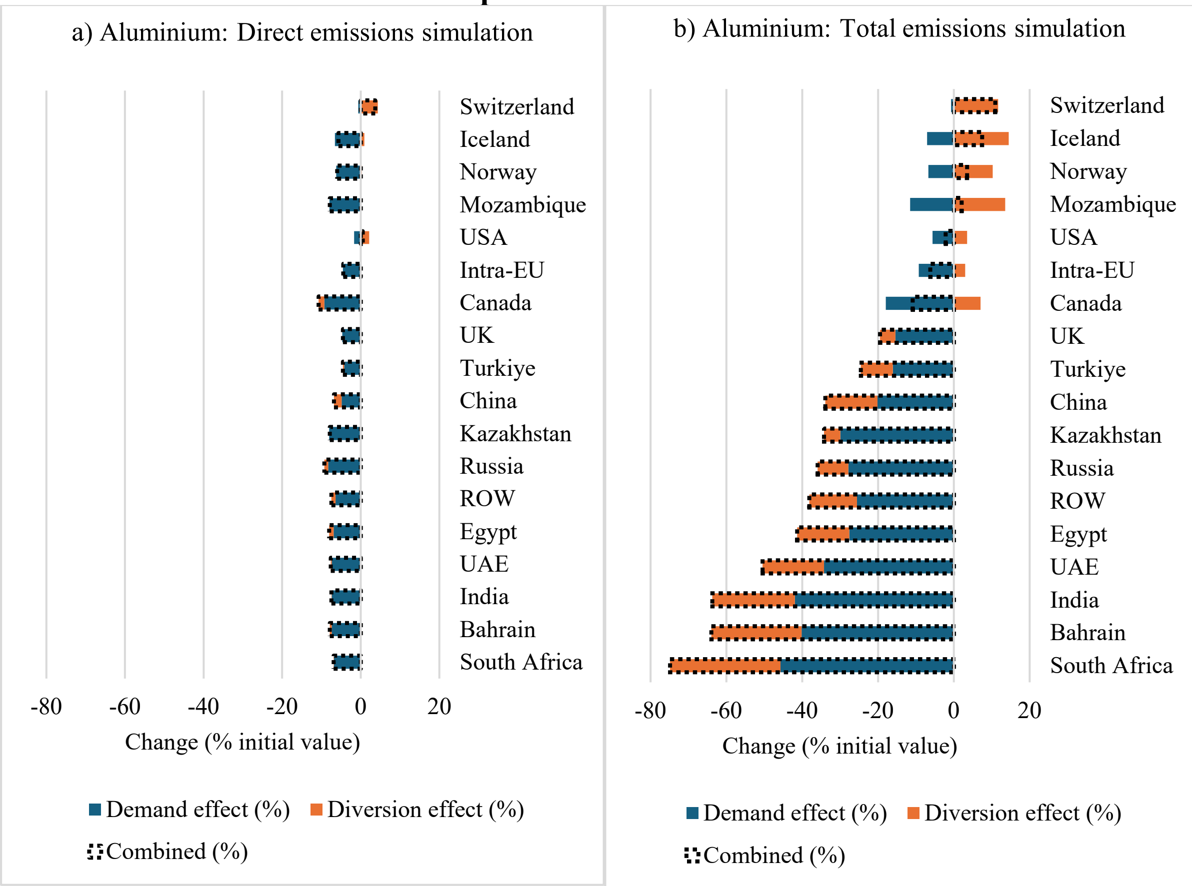
Appendix A

Table A.1: EU imports of iron & steel and aluminium products by major source - product-level breakdown

Industry & CN 8 code	Description	Countries (share product in industry imports from country %)
Aluminium		
76011000	Aluminium, not alloyed, unwrought	Iceland (25.4), India (38.4), Mozambique (55.8), Russia (36.6), South Africa (36.3)
76011090	Aluminium, not alloyed, unwrought (excl. slabs)	Canada (56.5), Egypt (18.9), Kazakhstan (51.8)
76012020	Unwrought aluminium alloys in the form of slabs or billets	Bahrain (25.2), EU (8.0), Norway (37.1), ROW (12.3), UAE (28.4), UK (20.0)
76042990	Solid profiles, of aluminium alloys, n.e.s.	Türkiye (23.8)
76061292	Plates and sheets, of aluminium alloys, thickness > 0,2 mm but < 3 mm, square or rectangular	Switzerland (27.0)
76169990	Articles of aluminium, uncast, n.e.s.	China (23.1), US (23.2)
Iron & steel		
26011200	Agglomerated iron ores and concentrates (excl. roasted iron pyrites)	Brazil (19.1), ROW (9.3), South Africa (50.8), Ukraine (30.2)
72071210	Semi-finished products of iron or non-alloy steel, containing by weight < 0,25 of carbon, of rectangular cross-section, width >= twice thickness, rolled or continuous casting	Russia (43.1)
72083700	Flat-rolled products of iron or non-alloy steel, width >= 600 mm, in coils, simply hot-rolled, not clad, plated or coated, thickness >= 4,75 mm to 10 mm, not pickled, without patterns in relief	Serbia (11.2)
72083900	Flat-rolled products of iron or non-alloy steel, width >= 600 mm, in coils, simply hot-rolled, not clad, plated or coated, thickness < 3 mm, not pickled, without patterns in relief	Japan (19.1)
72104900	Flat-rolled products of iron or non-alloy steel, width >= 600 mm, hot-rolled or cold-rolled, not corrugated, plated or coated with zinc	South Korea (11.5), Taiwan (7.7), Türkiye (7.6)
72107080	Flat-rolled products of iron or non-alloy steel, width >= 600 mm, hot-rolled or cold-rolled, painted, varnished or plastic coated	India (7.2)
72142000	Bars and rods, of iron or non-alloy steel, with indentations, ribs, grooves or other deformations produced during the rolling process	Belarus (14.6), Norway (18.6)
72189110	Semi-finished products of stainless steel, of rectangular cross-section, containing by weight >= 2,5% nickel	UK (7.9)
73269098	Articles of iron or steel, n.e.s.	China (19.7), EU (6.0), Switzerland (12.1), US (18.7)

Appendix B

Figure B.1: Percentage change in EU imports of aluminium products from each country in response to the EU CBAM

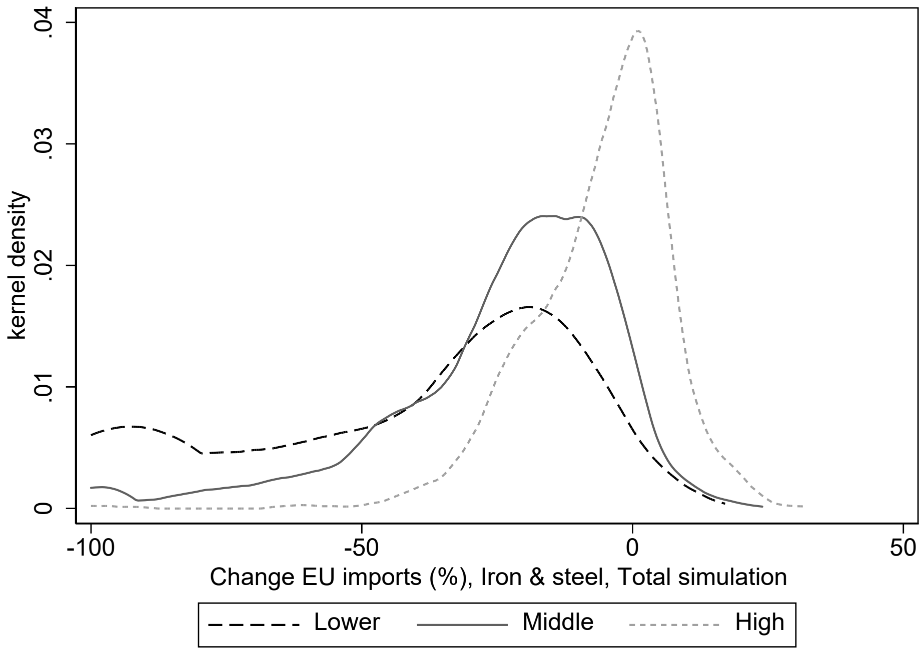


Notes: Model results based on carbon price of 80 EUR/tCO₂e.

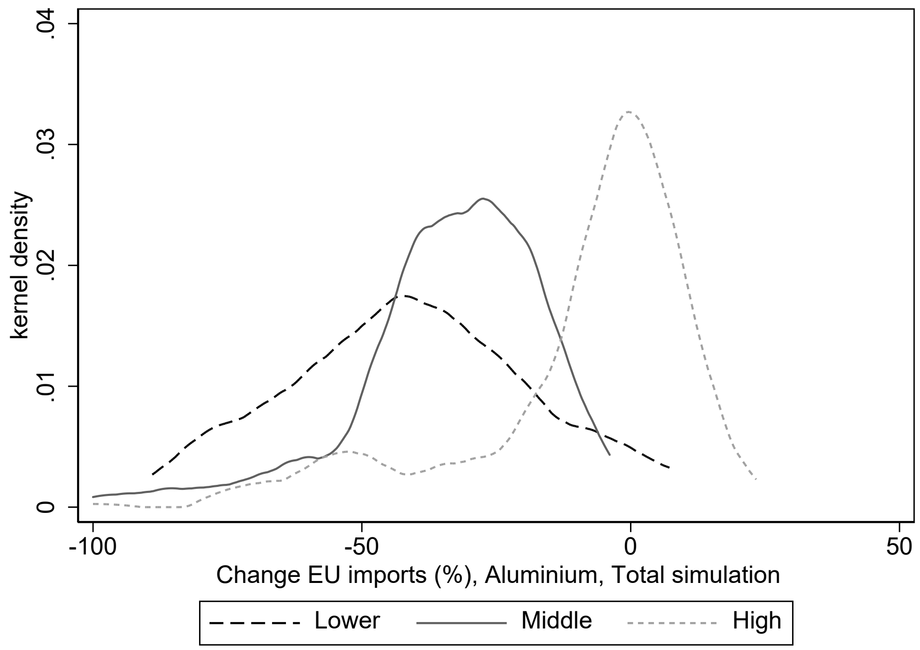
Appendix C

Figure C.1: Distribution of simulated changes in EU import value by exporter income group – total emissions simulation

(a) Iron & steel



(b) Aluminium



Notes: Model results for the total emissions simulation based on carbon price of 80 EUR/tCO₂e.
Lower = Mozambique, India, Egypt; Middle = Ukraine, South Africa, Belarus, Brazil, China, Serbia, Kazakhstan, Russia, Türkiye; High = Bahrain, Japan, South Korea, EU, UAE, UK, Canada, USA, Iceland, Norway, Switzerland. Countries are classified as falling in the middle category if their GDP per capita in 2024 falls between USD 4,500 and USD 16,000. This classification differs from the World Bank income classification, where countries with Gross National Incomes per capita above USD 14,005 in 2024 are classified as high-income.