A model-based assessment of the EU-CBAM and an expansion of Carbon Border Adjustment Mechanisms across major economies

Dimitris Fragkiadakis, Ioannis Charalampidis, Zoi Vrontisi, Eleni-Christina Gkampoura
E3 Modelling, Athens, Greece

Abstract

This study investigates the macroeconomic and trade implications of the European Union's Carbon Border Adjustment Mechanism (CBAM) and its potential global expansion using the GEM-E3 general equilibrium model. By formulating three scenarios of increasing CBAM adoption, we assess the economic implications on GDP, trade patterns, and sectoral performance. The results confirm that CBAM has only limited economy-wide and global macroeconomic implications, with total GDP effects remaining small across all scenarios, with GDP changes ranging from -0.02% to -0.11%.Global greenhouse gas emissions and aggregate trade volumes are likewise only marginally affected, even under wider international adoption of CBAM. Country level impacts are determined by fossil fuel dependance and emission intensity in the production of CBAM-related sectors. Countries implementing CBAM, notably the EU, experience a reallocation of competitiveness: while CBAM-covered sectors are partially insulated from carbon leakage, the economy-wide outcome is shaped by indirect effects on downstream activities. Countries with cleaner production profiles, such as Japan and South Korea, record higher competitiveness due to lower export costs and experience GDP gains. A central finding is that downstream and upstream sectors not directly covered by CBAM account for a large share of the aggregate economic adjustment, emphasizing the need for coordinated policy design and transitional support for vulnerable economies.

Key words

CBAM, EU CBAM regulation, trade patterns

Highlights

- **Across all scenarios, CBAM results in small global GDP and GHG emissions effects**, with GDP changes ranging between -0.02% and -0.11%.
- Iron and steel sector is more affected by the imposition of carbon border taxes, along with downstream and upstream sectors that are also affected.

- Countries implementing CBAM, particularly the EU, face a redistribution of competitiveness, where gains in protected sectors are partly offset by losses in non-CBAM manufacturing and services.
- The EU's CBAM reshapes CBAM products' global trade: India faces the steepest export decline (-23%) in CBAM exports, while countries like the USA, Canada, and Australia capitalize on the shift, gaining market share as greener production becomes a competitive edge.

Introduction

Over the past years, governments worldwide have faced a double challenge: on the one hand there is a need to implement stricter climate policies and on the other hand they have to minimize the impact from higher emission-related costs which can be detrimental to the competitiveness of domestic industries and could shift production to other countries. This risk, most known as carbon leakage, poses a threat not only from an economic point of view but also from a climate perspective as it hinders the effectiveness of policies (potentially) increasing rather than reducing global emissions.

For the EU, which has committed to deep decarbonization, this problem becomes increasingly pressing, and stricter standards need to be balanced with fair competition for European producers and real progress on climate goals. In response to this challenge, the European Commission announced in 2023 the adoption of a carbon adjustment mechanism (EU CBAM Regulation 2023/956), as an indispensable part of its ambitious climate policy, which would lead to a 55% reduction in emissions by 2030 and to climate neutrality by 2050.

The CBAM is a climate policy tool that aligns the cost of imports based on their carbon content, with the cost paid by EU producers under the Emissions Trading System (EU ETS). The implementation of the CBAM is twofold: on the one hand to protect vulnerable European industries which are prone to competitiveness losses and carbon leakage, on the other hand to incentivize exporters to the EU to adopt more environmentally friendly production processes. As we have not yet reached a consensus on global action and effort sharing to combat climate change, it is highly likely that, in a world of unilateral climate action, more countries will follow the example of the EU by adopting similar mechanisms. Already several countries are exploring the introduction of Carbon Border Adjustment Mechanism (CBAM) such as the United States, China, Canada, Australia, and Japan begin exploring similar measures.

In the United States, for instance, discussions around carbon pricing and border adjustment mechanisms have gained traction, with bipartisan support emerging for policies that reflect aspects of the EU's CBAM. China, the world's largest emitter of greenhouse gases, has signaled its intention to transition toward a greener economy and may eventually adopt a CBAM-like system to protect its industries from competitive disadvantages in global markets. Likewise, Japan has been actively examining ways to incorporate carbon considerations into its trade policy.

Canada, a major exporter of natural resources, is closely monitoring the EU's CBAM as it considers similar measures to complement its domestic climate policies. Introducing a Canadian CBAM could help protect its carbon-intensive industries from trade disadvantages, align with international climate efforts, and maintain competitiveness in global markets. Australia has also engaged in discussions on carbon pricing and climate action, although it has historically adopted a more cautious stance toward stringent carbon regulations. The country's major export sectors, such as coal, iron ore, and agricultural products, are highly carbon-intensive and could face significant challenges under CBAM policies. To address these concerns, Australia's Safeguard Mechanism[1], which outlines measures to reduce emissions from large industrial facilities, is considering options to mitigate carbon leakage, including the potential introduction of a CBAM[2].

The potential adoption of CBAM by these countries could fundamentally reshape global trade dynamics and climate policy. As more nations implement similar mechanisms, international supply chains will need to adapt to a more fragmented regulatory landscape, where carbon content becomes a critical factor in determining the pricing and competitiveness of goods.

Carbon tariffs primarily target energy- and carbon-intensive industries, with the EU's CBAM focusing on sectors such as iron and steel, aluminum, fertilizers, and cement. China is a major exporter in most of these industries, particularly iron and steel, while Canada, Türkiye, and countries in the Middle East and North Africa also play significant roles. Trade patterns reveal strong dependencies[3]: for example, Türkiye and the UK export large shares of iron and steel to the EU, and Canada is heavily reliant on the U.S. market. In aluminum, Türkiye, India, China, and the UK are key suppliers to the EU, while fertilizer exports from Türkiye and the UK largely go to the EU, with India being a major destination for Chinese and Indonesian fertilizers. Cement trade, by contrast, is shaped primarily by geographic proximity.

In this paper we conduct a model-based assessment of the EU CBAM but also consider the expansion of border adjustment mechanisms in large economies, as described above. The analysis is performed with the large-scale CGE model, GEM-E3, exploring three scenarios with increasing global adoption of CBAM measures, and focuses on macroeconomic and trade implications, exploring the export impacts and the bilateral trade shifts in CBAM-regulated products across major economies. It also quantifies the indirect impacts on downstream and upstream sectors which significantly influences the economic gains from CBAM adoption. Finally, our analysis expands beyond the aggregate trade impacts and includes also changes on bilateral trade flows, providing insights regarding the potential change of bilateral trade relationships in the presence of carbon tariffs. By jointly analysing sectoral, value-chain and macroeconomic responses, the paper

[1] https://www.dcceew.gov.au/climate-change/emissions-reporting/national-greenhouse-energy-reporting-scheme/safeguard-mechanism

[2] https://www.dcceew.gov.au/climate-change/emissions-reduction/review-carbon-leakage

[3] For more detailed information on trade status and global production in selected energy-intensive industries, see Appendix 1.

demonstrates that the overall economic relevance of CBAM lies less in aggregate GDP or emissions outcomes—which remain small—and more in the reallocation effects within implementing economies and along international value chains. The paper is structured as follows: in Section 2, we conduct a detailed literature review regarding studies focusing on CBAM. In Section 3, the description of our methodology is presented, including the model definition and the scenario design. Section 4 presents the results and Section 5 concludes the paper.

Literature Review

The assessment of Carbon Border Adjustment Mechanisms (CBAM) and their implications for the economy and greenhouse gas (GHG) emissions has been a central topic in Computable General Equilibrium (CGE) impact assessment studies for over two decades. Early research, particularly in the 2010s, focused on evaluating alternative policy options to limit carbon leakage and to protect energy-intensive industries from competitiveness losses under unilateral climate action.

Kuik and Hofkes (2010), using a multi-sector, multi-region CGE model, analyzed the effects of border adjustment measures within the EU ETS. Their findings indicate that such measures can substantially reduce carbon leakage in sectors such as iron and steel, while the effect is smaller for mineral products, including cement. However, the overall leakage rate declines only modestly. Similarly, Fisher and Fox (2011) examined four anti-leakage policies (import charges, export rebates, full border adjustments, and output-based domestic rebates) within a unilateral carbon pricing framework. They concluded that full border adjustment is often the most effective option for limiting leakage and competitiveness impacts, though output-based rebates can capture some benefits for key energy-intensive sectors.

Building on this, Böhringer et al. (2012) compared three instruments (border tax adjustments, industry exemptions, and output-based allocation) and found border adjustments to be by far the most effective, reducing leakage by one-third to one-half, compared to less than 15% for the other measures. Their analysis also showed that border measures strongly mitigate output losses in energy-intensive, trade-exposed (EITE) industries. The EMF 29 model-comparison study (Böhringer, Balistreri, and Rutherford, 2012) confirmed these findings: border carbon adjustments significantly reduce emission leakage (from 12% to about 8%) and competitiveness losses, with EITE production falling by only ~1% under BCA versus ~2.8% without it.

Overall, border carbon adjustment (BCA) seems to consistently emerge as the most effective instrument for reducing carbon leakage and protecting competitiveness among energy-intensive sectors.

Interest in CBAM surged following the EU's adoption of the mechanism, shifting research toward quantifying country-specific impacts on trade flows, GDP, and employment. Acar, Aşıcı, and Yeldan (2021) estimated that Turkish exporters to the EU could face a "carbon bill" of €1.1–1.8 billion annually under carbon prices of €30–50 per tonne, with GDP losses of 2.7–3.6% by 2030 under a business-as-usual scenario. Ramadhani and Koo (2022), using the GTAP-E CGE model, found that carbon border taxes negatively affect Indonesia's trade and economy, though introducing even a low domestic carbon tax helps mitigate these impacts. They also noted that current CBAM levels are insufficient to incentivize non-regulated countries to adopt stringent mitigation policies.

Gu et al. (2023) assessed CBAM's effects on BASIC[4] countries using a GTAP CGE model, finding reductions in economic development, welfare, trade, and energy-intensive industry output, with electricity output declining by over 5%. Beaufils et al. (2023) analyzed the impacts of different EU CBAM designs on global trade using a detailed throughflow accounting approach. They show that middle- and low-income countries that depend on exports to the EU are disproportionately affected, even under conservative CBAM designs, and explore revenue-recycling schemes to enhance inclusivity and support international climate cooperation. Clora et al. (2023) explored alternative CBAM designs under different international response scenarios, showing that stricter designs reduce leakage more effectively, but retaliation offsets these gains and increases costs for EU EITE sectors. Bellora and Fontagné (2022), using a dynamic CGE model, found that the most ambitious CBAM scenario reduces cumulative carbon leakage from 20.7 $GtCO_2eq$ (~76.1%) to 8.5 $GtCO_2eq$ (~31%), while the CBAM design option increases the EU ETS carbon-quota price by ~5.2%.

Several recent studies examine CBAM's implications for China. Chen (2023), using a dynamic recursive CGE model, found that CBAM reduces output and exports in EITE sectors, with sectoral impacts depending on carbon price scenarios and CBAM design. Yan et al. (2025) evaluated how the EU's CBAM affects China's macroeconomy, industry output, and power sector, finding that the implementation of CBAM leads to a decline in China's GDP compared to a benchmark scenario, and that output in high-energy-consuming industries such as steel and aluminum also falls under the CBAM policy. Ren et al. (2025) developed a multi-scenario MRIO framework to assess the effects of CBAM on China's provisional exports to the EU. They find that across covered industries, estimated additional levies range from $0.07 billion to $2.25 billion depending on scope and carbon-pricing scenario.

Chu et al. (2024) applied CGE and partial-equilibrium models to Vietnam, concluding that CBAM's macroeconomic impact is minimal due to the small share of affected exports, though sectoral impacts on steel, aluminum, and cement are significant. Similarly, Takeda and Arimura (2024) found that CBAM reduces EU carbon leakage but has negligible GDP and welfare effects globally, with Japan experiencing slight gains despite modest EITE sector losses. Jebeli et al. (2025) examined BCAs for Canada, finding that participation in a coalition of BCA-implementing countries reduces leakage and improves competitiveness, with design features like export rebates further shaping sectoral outcomes.

Recent work highlights distributional and spillover impacts. Amendola (2025), using a MRIO framework, found limited evidence of burden shifting to non-EU countries, but highlighted notable redistributive effects within the EU, particularly for some Eastern Member States, and noted competitiveness and carbon leakage risks in downstream industries. He et al. (2025) employed a

[4] BASIC countries: China, India, Brazil, South Africa

recursive dynamic CGE model to quantify the spill-over effects of the EU's CBAM on a range of countries, including many developing countries. Their simulation results indicate that CBAM may widen the gap between developed and developing countries in terms of GDP and welfare, thereby potentially eroding the decarbonisation capacity of low-income countries. Bye et al. (2025) examined the potential impacts of CBAM on industrial sectors. They note that energy-intensive industries may experience cost pressures associated with the introduction of CBAM and discuss possible measures to mitigate leakage. The study does not provide detailed numerical estimates of sectoral output or export losses.

Several studies explore integrated climate policy designs. Tsakiris and Vlassis (2024) show that public pollution abatement in exporting countries can unintentionally raise carbon leakage under stricter import regulations, and propose conditional BCAs to align carbon taxes and improve global welfare. Delgado-Téllez et al. (2025 find that combining higher EU carbon prices with BCAs reduces emissions but also causes GDP losses due to increased energy costs and network effects.

The EU Commission's Impact Assessment (2022), using the JRC-GEM-E3 CGE model, confirmed that energy-intensive sectors remain most exposed to leakage under current EU climate policies. More ambitious CBAM designs mitigate this risk more effectively, particularly for the hardest-hit sectors, while design choices strongly influence leakage outcomes and sectoral impacts.

In summary, the literature consistently shows that CBAM and related border adjustment measures can significantly reduce carbon leakage and competitiveness losses in energy-intensive sectors, though their macroeconomic impacts are generally modest. Design choices and international responses play a critical role in determining effectiveness, and retaliation can offset some gains. Recent studies have largely focused on unilateral or EU-specific CBAM scenarios, with limited exploration of coordinated global adoption.

Our paper addresses this gap by conducting a model-based assessment of the EU CBAM and examining the implications of expanding border adjustment mechanisms to large economies. Using the large-scale hybrid CGE model GEM-E3, we explore three scenarios with increasing global CBAM adoption. The analysis focuses on macroeconomic and trade impacts, including export performance and bilateral trade shifts in CBAM-regulated products across major economies, providing new insights into the systemic effects of broader CBAM implementation.

Methodology

To assess GEM-E3 is a large scale multi-sectoral hybrid CGE model designed to evaluate the effects of external shocks on the economy[5]. The model provides a robust framework to capture the complex energy-economy-climate interactions and simulate the impact of climate and energy

[5] For a detailed presentation of the model please read https://e3modelling.com/modelling-tools/gem-e3/ - model manual.

policies on the performance of sectors, sectoral output, prices and bilateral trade, the competitiveness of regions and the welfare of communities. Results have a yearly frequency up to 2030 and 5-year time steps until 2050/2100. The model has a global coverage, with 47 regions (see Appendix), where the G-20 countries, EU27 Member States, and major equipment manufacturing or energy exporting countries are represented individually and are also linked through bilateral trade. All countries are linked through endogenous bilateral trade transactions. The model explicitly represents 50 distinct economic activities (see Appendix 2), which are interlinked across the production and consumption value chain.

Focus is placed on the representation of the energy system where specialized bottom-up modules of the power generation, buildings, and transport sectors. To this end, the model includes a detailed representation of the power generation system (12 power technologies) and a detailed transport module (private and public transport modes), while different technological options for energy use in buildings and industry are provided. The energy system representation includes an explicit representation of new technologies such as hydrogen, clean fuels, and bioenergy options.

The GEM-E3 environmental module covers all GHG emissions and a wide range of abatement options, as well as a thoroughly designed carbon market structure (e.g., grandfathering, auctioning, alternative recycling mechanisms). The model has been used extensively by the European Commission, World bank, governments, and public institutions to assess the macroeconomic, distributional and employment implications of the transition to climate neutrality.

The model is based on advanced applied modelling techniques and has been further extended to allow the representation of semi-endogenous technical progress, endogenous formation of labor skills and human capital and a detailed bottom-up representation of the energy system (transport and power generation), along with non-CO_2 emission abatement options and negative emissions technologies. It features involuntary unemployment in the labor market and alternative macroeconomic closures supported by a detailed representation of the financial sector. The model is established on rigorous microeconomic theory, it is empirically estimated (substitution and trade elasticities) and can undertake long term analysis as opposed to econometric models that suffer from the Lucas critique. The model can be used both in a comparative and what if analysis frameworks as represents a closed and consistent accounting of resources.

The model is calibrated to a wide range of datasets comprising of IO tables, energy balances, GHG inventories, bilateral trade matrices, investment matrices and household budget surveys. All countries in the model are linked through endogenous bilateral trade transactions identifying origin and destination. The substitution elasticities of the model are not derived from the general literature but are estimated according to its dimensions and functional forms using the latest available datasets. The model is recursive dynamic through the accumulation of capital via the decision for investments and through the accumulation of knowledge stocks via R&D. Model regions are linked through endogenous bilateral trade following the Armington assumption of imperfect substitution across domestic and imported goods. The nested production functions are differentiated by sector and follow a CES structure. For the demand side, the model simulates consumer behavior and maximizes a Klein-Rubin utility function that results in a Linear Expenditure demand system subject to its disposable income not used for obliged consumption (subsistence minima consumption) and after allowing for the decision on savings. The representative household decides on the allocation of its available for consumption income over different consumption categories (COICOP), distinguishing between durable and non-durable goods. The model has been calibrated to the latest statistics (GTAP 11, IEA, UN, ILO) while Eurostat statistics have been used for the EU.

The model is written in a structural form and can be used for the comparative analysis of alternative policy scenarios and the provision of insights on the distributional effects of long-term structural adjustments. In all simulation alternatives the model ensures that the economic system is always in general equilibrium. The GEM-E3 model is written entirely in GAMS.

The most important results, provided by GEM-E3 are: Full Input-Output tables for each country/region identified in the model, GDP and GDP components, employment by economic activity and by skill and unemployment rates, capital, interest rates and investment by country and sector, private and public consumption, bilateral trade flows, consumption matrices by product and investment matrix by ownership branch, GHG emissions by country, sector and fuel and detailed energy system projections (energy demand by sector and fuel, power generation mix, deployment of transport technologies, energy efficiency improvements).

GEM-E3 enables a thorough understanding and detailed identification of risks and opportunities of the low carbon transition and of the implementation of specific climate and energy policies by capturing:

- Direct impacts on each sector, e.g., how carbon prices and carbon border taxes will affect a sector's costs of production (considering carbon intensity) and thus its production levels (via domestic and international demand)
- Indirect impacts via value chain effects (e.g. changes in prices of intermediate products, of labour and capital inputs), technology costs, consumer preferences, material availability and costs
- Induced effects via economy feedback, prices, and income implications (e.g. overall drop of demand even for products not directly affected by carbon prices etc.)
- The impacts of financing requirements (capital-intensive process of mitigation) and different financing options

With respect to the simulation of CBAM implementation in the model the following assumptions are made:

- CBAM is introduced as a tariff which is calculated as the product of the emissions of the exporter multiplied by the difference in carbon price between the two countries

- The model includes a mechanism that enables a shift in the production process of exported goods due to the CBAM signal. Although typically in model-based assessments tariffs do not enter the optimization problem of the firm to minimize the cost of production, in the GEM-E3 model we introduce a carbon value associated with the CBAM rate to put a shadow cost on emissions that gives incentives to exporters to adopt more efficient production processes. This carbon value is not actually paid by the producers (exporters), and thus not included in the unit cost of production, as it is then refunded at the level of the producer price. This approach allows us to internalize the external costs of carbon tariffs and induce carbon reductions beyond those associated with changes in activity levels.

- The sectoral representation in the model is of lower granularity than that of the CBAM products. To align with the CBAM framework, we utilize data from Eurostat (ESTAT:DS-018995) and the UN Comtrade Database[6], which allow us to estimate the share of CBAM products within each aggregated sector to more accurately represent impacts on bilateral trade flows of CBAM goods.

Scenario design

The impact assessment examines alternative adoption rates of CBAM by major economies. The scenario results are drawn against a reference case which on the macro level is aligned with the most recent projections delivered by IMF, OECD and European Commission for economic variables while demographics and labor market projections are drawn from ILO and UN. With respect to climate ambition, the EU achieves a 55% emission reduction by 2030 in line with the Fit-for-55 package while by 2050 it achieves NETZERO GHG emissions. Non-EU countries are assumed to achieve their NDC targets by 2030, while for the period up to 2050, climate ambition remains constant to the respective NDC, by assuming a continuation of the implicit carbon price to 2050 (only increasing with GDP growth rates).

In total 3 alternative scenarios are quantified, reflecting increasing adoption rates of CBAM measures by major economies. The first scenario assesses the impacts of the EU CBAM, the second scenario assumes that a second group of countries, namely the G1 group including USA, UK, Japan and Australia also adopt carbon border taxes for the same products that are subject to the EU CBAM, while the third scenario assumes that on-top of the G1 group China, India and Canada imposes carbon taxes on imports (Table 1). The products covered by all the assessed CBAM schemes are specified in the EU CBAM Regulation (EU) 2023/956.

Table 1: Scenario design and specifications

	Reference	NDC+EU CBAM	NDC+G1CBAM	NDC+G2CBAM
EU climate policy	Fit-for-55 extended to net zero GHG to 2050			
Global climate policy	NDC	NDC	NDC	NDC

[6] https://comtradeplus.un.org/TradeFlow

EU CBAM	No	EU CBAM Regulation (EU) 2023/956	EU CBAM Regulation (EU) 2023/956	EU CBAM Regulation (EU) 2023/956
Other CBAM	No	No	Border Carbon Adjustment schemes in **Group 1** countries: Australia, USA, UK and Japan considering domestic carbon pricing schemes or implicit carbon values from emission targets	Border Carbon Adjustment schemes in **Group 1 plus Group2 countries:** Canada, China and India considering domestic carbon pricing schemes or implicit carbon values from emission targets
Sectors under CBAM	No	cement, iron and steel, aluminium, fertilisers, hydrogen, and electricity		

Dynamics in international trade under CBAM, will be largely determined by relative GHG intensities. According to data published the World Bank, most countries and especially India and China are more energy intensive relative to products produced in EU, Japan and USA. This implies that higher tariffs would be imposed in Chinese and Indian products, potentially leading to market share losses (see Appendix 2).

Another factor that determines the value of the CBAM associated tariffs is the carbon price in the exporting country. The scenario implementation assumes that the CBAM introduction is associated with a domestic carbon pricing scheme, similarly to the EU-ETS, to justify the tariff introduction for climate mitigation purposes. Table 2 presents the carbon value estimated by the model to achieve the respective NDC targets, in the countries of interest. The level of carbon pricing needed to meet the NDC targets is largely related to the emission levels of the assumed baseline scenario, namely the scenario that considers the implementation of currently legislated policies with no achievement of NDCs. For example, Australia would need a relatively high carbon price to achieve its decarbonization targets, while in Türkiye and Indonesia the NDC implementation only requires a low carbon price on top of the current policies. The difference between the domestic and importer's carbon price defines the CBAM rate and can lead to higher/lower (export) price increases compared to other countries.

When considering all alternative scenarios, the EU27 imposes the highest tariffs among other major economies, due to the highest domestic carbon price associated with the ambitious NDC and Net zero targets. which is largely explained by the difference in emission targets. EU27 is assumed to achieve NETZERO by 2050, the associated carbon price reaches 403 € per ton emitted while in the non-EU countries, except for Australia and United Kingdom, carbon taxes are lower than 90 € per ton of CO_2 emitted.

Table 2: Carbon price in GEM-E3 reference scenario with NDC implementation (€/ton CO2)

	2030	2040	2050
China	5	7	8
India	19	28	41
Indonesia	3	4	4
Japan	44	48	51
Korea, Rep.	75	84	88
Australia	146	187	234
Türkiye	1	2	3
United States	65	74	84
Canada	35	43	52
Brazil	20	27	36
United Kingdom	226	272	331
EU27	168	286	403

Results

The macroeconomic impacts of CBAM are primarily shaped by three mechanisms: the carbon cost differential embedded in border tariffs, international trade linkages, and indirect value-chain spillovers affecting sectors not directly covered by CBAM. Importantly, the results show that CBAM does not generate large economy-wide or global effects, even under broader international adoption.

Across all scenarios, changes in global GDP and trade remain limited, confirming that CBAM operates mainly as a redistributive rather than a contractionary policy at the global level. At the same time, for CBAM-implementing economies such as the EU27, indirect downstream impacts dominate the aggregate outcome, offsetting a substantial share of the gains recorded in energy-intensive, CBAM-covered industries. Global GDP changes remain small, ranging between −0.02% and −0.09% under EU-only CBAM and reaching at most −0.11% when CBAM is adopted by the widest coalition of countries (CBAMG2). These magnitudes remain modest throughout the projection period and increase gradually only after 2035, when CBAM is fully phased in and carbon prices rise more steeply (Figure 1). Similarly, aggregate impacts on global trade are marginal. Total world exports decline by around 0.1% in the EUCBAM scenario and by approximately 0.14–0.15% in the CBAMG1 and CBAMG2 scenarios. These limited changes indicate that CBAM does not constitute a major negative demand shock for the global economy, but rather induces reallocations of trade flows across regions and sectors.

Global greenhouse gas emissions are only marginally affected. While emissions decline in CBAM-regulated sectors, these reductions are partly offset by changes in production patterns and trade flows elsewhere, resulting in limited net global effects. This confirms existing findings in the literature that border adjustment mechanisms primarily operate as leakage-mitigation and competitiveness instruments, rather than as drivers of large-scale global decarbonisation.

Taken together, these results indicate that CBAM does not materially alter global economic growth paths or emissions trajectories. Instead, its primary effects emerge through relative price changes and sectoral reallocation within and across countries.

For CBAM-implementing economies—most notably the EU27—the aggregate GDP impact remains small but masks substantial internal reallocation effects across sectors and demand components. In the EU27, cumulative GDP losses over 2025–2050 amount to approximately 0.0033–0.0035% across scenarios (around €147–154 billion), with slightly lower losses observed as more countries adopt CBAM (CBAMG1 and CBAMG2). This reflects relative competitiveness gains for EU producers as carbon pricing becomes more widespread internationally. The same holds for USA, where GDP losses are found to be lower in CBAMG2 compared to CBAMG1 (-13.4 bn.€ compared to -15 bn.€).

However, decomposition of GDP effects reveals that these aggregate outcomes are driven primarily by trade and downstream cost effects that can counterbalance a potential expansion of CBAM-covered industries. In the EU27, exports are the dominant channel, with total exports declining by 0.63–0.66% in cumulative terms despite improved performance in CBAM-covered products under wider CBAM adoption. This decline is explained by reduced competitiveness of non-CBAM manufacturing sectors, whose production relies heavily on CBAM-covered intermediate inputs.

The contrast with other CBAM-implementing economies illustrates this mechanism. Japan and South Korea—characterised by relatively low CO_2 intensity in iron and steel production—record small but positive GDP effects, driven by increased exports of CBAM-covered products (Figure 1). In these cases, cleaner production profiles translate into lower effective carbon border costs and competitiveness gains without generating the same scale of downstream cost pressures observed in the EU.

A common finding for most countries is that imports fall as a response to CBAM measures, either due to the competitiveness improvement of domestically produced products or as a direct consequence of lower available incomes and higher prices for composite goods. The latter can also be the case not only in countries implementing CBAM but also in countries subject to CBAM that are importers of goods from the first group of countries (assuming no product differentiation is available as a model mechanism).

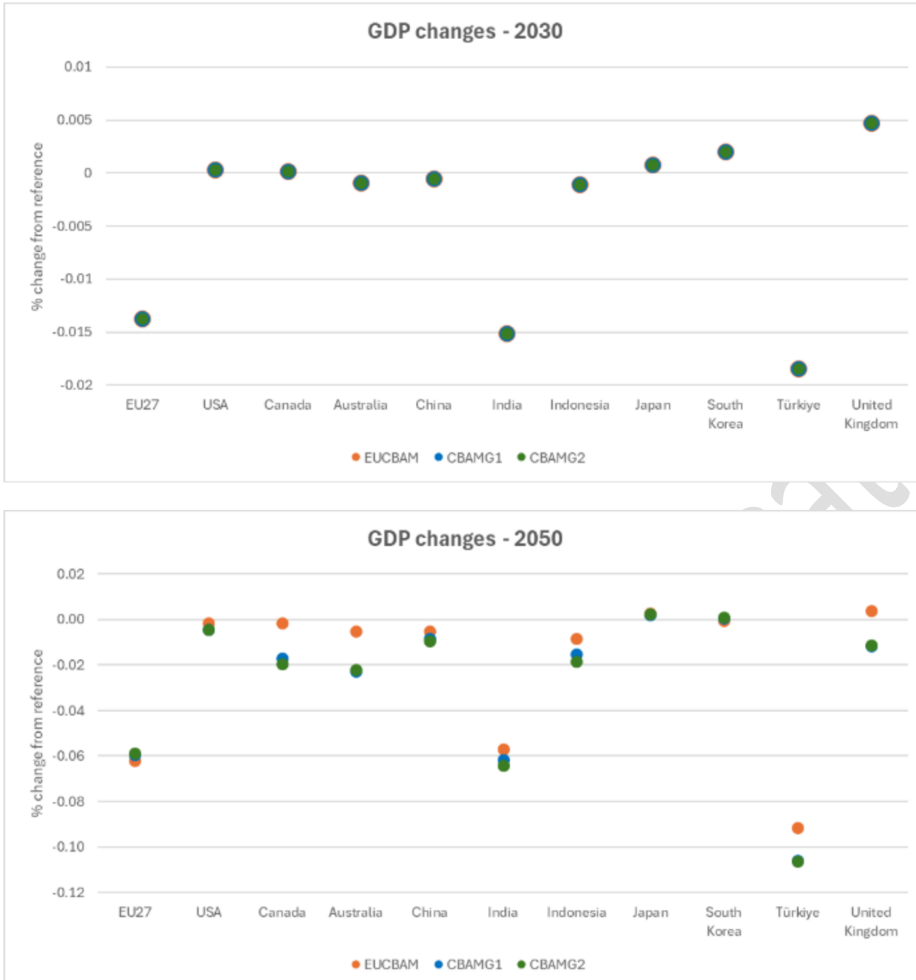


Figure 1: GDP changes (% change from reference)

Sectoral implications including indirect value chain effects

At the sectoral level, the iron and steel sector is affected the most to the imposition of carbon border taxes, compared to other sectors subject to CBAM. In India, GDP losses are driven mainly by drop in iron and steel exports, also indirectly affecting the intermediate demand and production of the fossil fuel sector. On average, cumulative production falls by 9% across scenarios, with the highest loss recorded in the EUCBAM (-10%). Lower production of the iron and steel sector is propagated in the economy through the energy channel, and energy sectors face decreased demand for their products, in particular the oil and coal sector. In Türkiye, in Türkiye this is the case for non-metallic minerals (which include cement for which Türkiye is one of the largest exporters worldwide) and chemicals (which include fertilizers). On average, exports of CBAM-related industries fall by 5.4% in the EUCBAM scenario, and by 6.4% in CBAMG1 and the CBAMG2 scenario, while total exports fall by 0.2% to 0.3%. In Japan and South Korea, the increase in GDP is driven primarily by the iron and steel sector, which is characterized by relatively lower CO_2 intensity compared to the rest of the non-

EU countries, hence the implementation of CBAM yields competitiveness increases for products produced there.

Beyond the CBAM sectors, a key contribution of this analysis lies in identifying indirect value-chain effects as the dominant transmission mechanism of CBAM. Across all scenarios, downstream and upstream sectors not directly regulated account for a large share of economy-wide adjustments.

In EU27, GDP losses are mainly associated with the change in competitiveness of downstream processes. Higher overall input costs, driven by CBAM tariffs, hinder the competitiveness of non-CBAM-related sectors. For example, in 2050 in the EUCBAM scenario, exports in non-CBAM manufacturing sectors fall by 1.1% compared to the reference and imports of those products increase by 0.75%. This is further amplified by the slightly negative income implications for the EU trading partners due to the imposition of the border adjustments. This leads to production losses which counterbalance the positive effect of the CBAM on energy intensive industries. Furthermore, due to differences in the labor intensity of sectors, employment and hence labor income, falls (-0.05%). At the same time, in the EU27, CBAM products (iron and steel, fertilizers, non-metallic minerals etc.) are expected to see a decline in the EUCBAM scenario (-1.2% compared to reference) but are expected to increase as more countries introduce CBAMs (+2.2% in CBAMG1 and +2.4% in CBAMG2). Overall and compared to other countries, the EU has the most notable losses in total exports across all scenarios, driven primarily by the relatively higher CBAM rate. This leads to higher production costs, through higher costs of intermediate inputs and especially in downstream sectors. In turn, this is translated into lower competitiveness in international markets. This effect is lower for other countries that adopt carbon border adjustment measures, as the tariff is directly linked to the level of national carbon tax.

Fossil fuel exports are also affected indirectly as intermediate goods for the production of CBAM products and can be one of the main drivers of export changes in countries like Indonesia, Australia and the USA. Overall exports of the energy sector are declining across all countries and scenarios, compared to the reference scenario, with the only exception of the UK, where energy exports are increasing by +0.73% to +0.75% across scenarios.

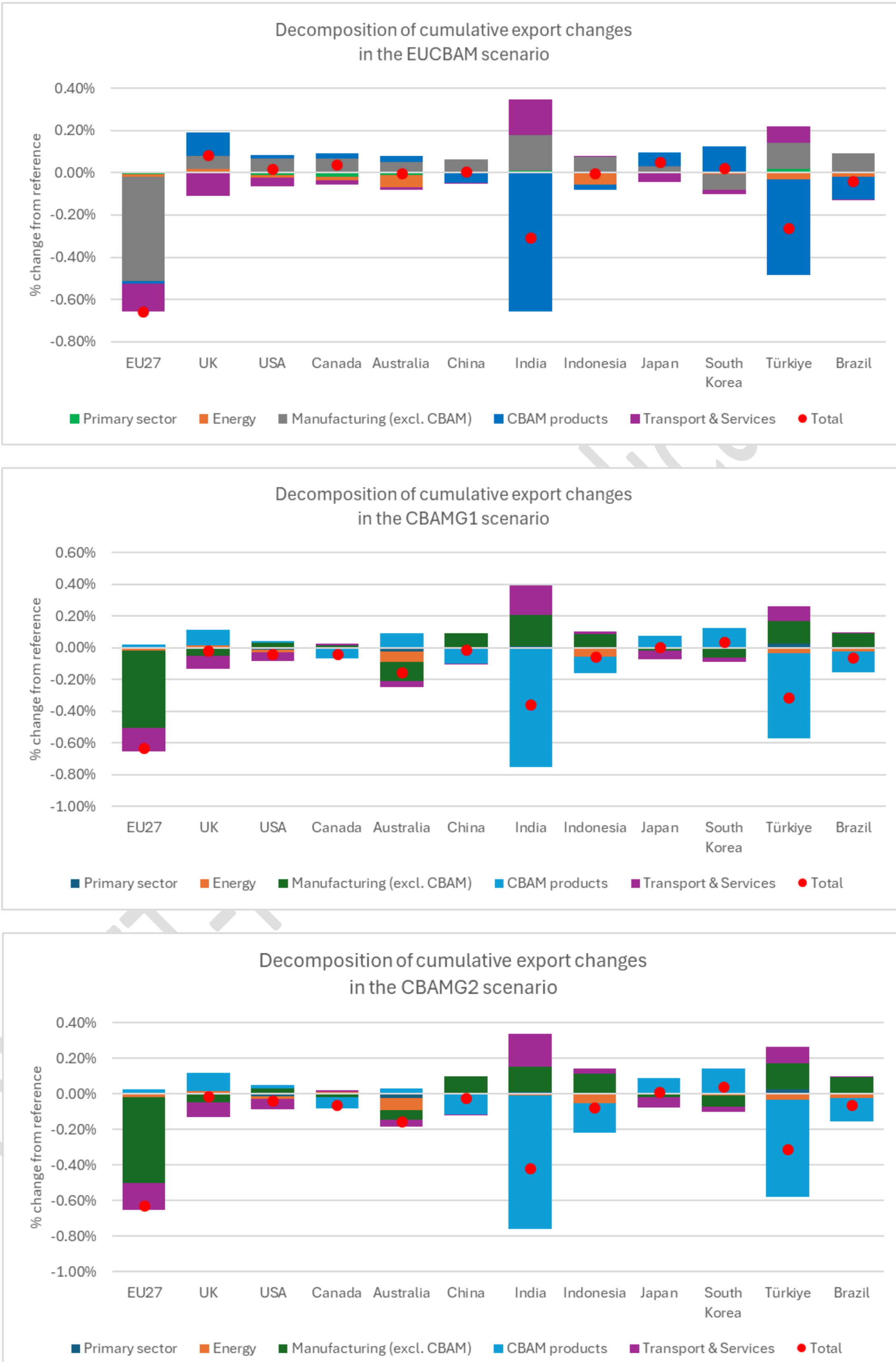


Figure 2: Decomposition of cumulative export changes

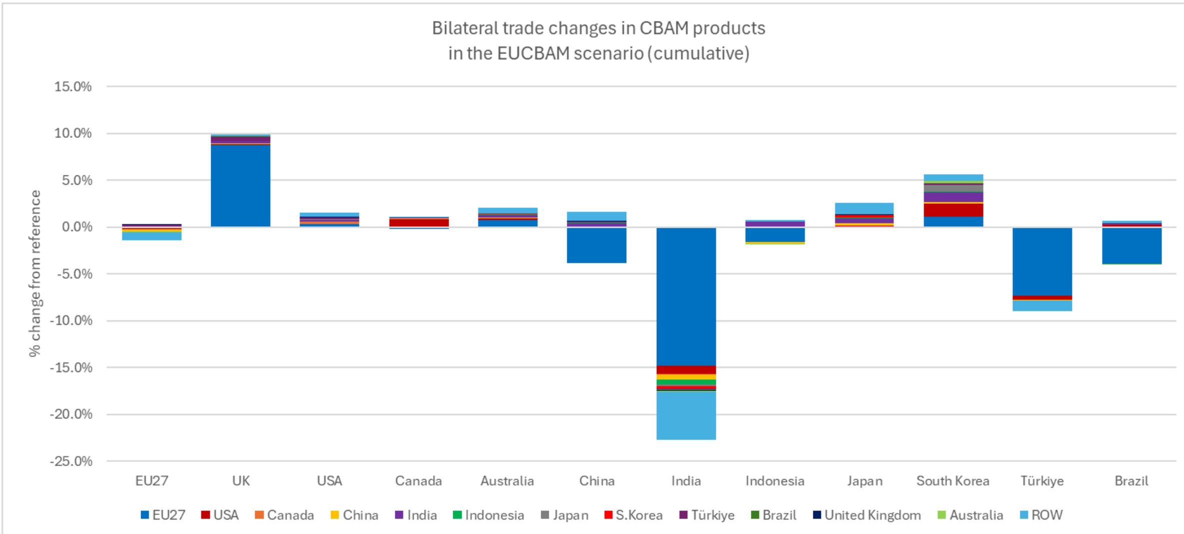
Trade reallocation and bilateral patterns

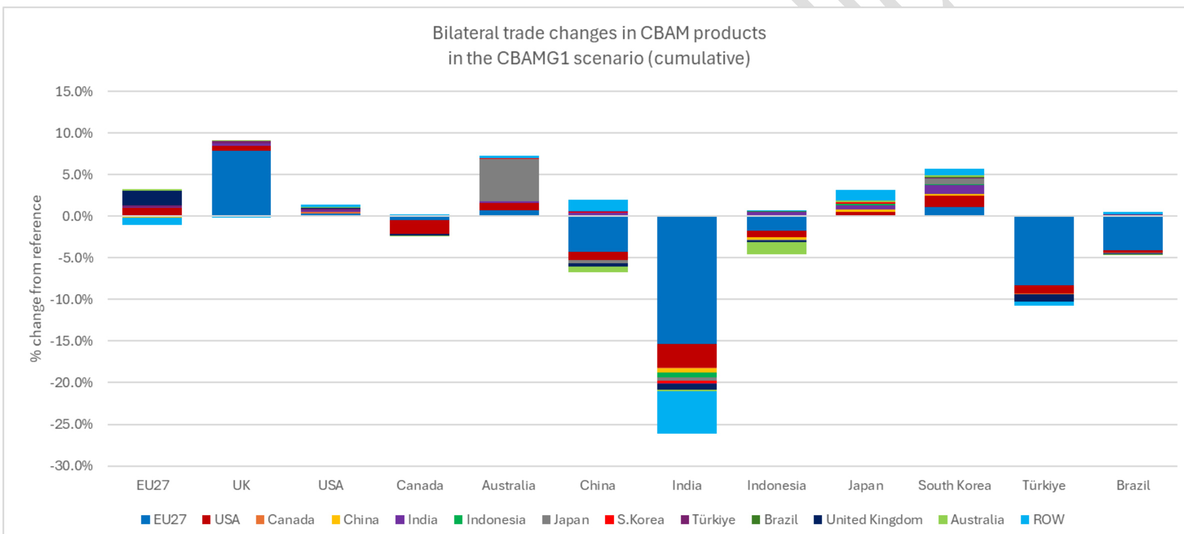
In the EUCBAM scenario, we identify two group of countries according to their export performance: i) the first group consists of China, India, Indonesia, Brazil and Türkiye and records a reduction in CBAM-related exports, and ii) a second group which consists of USA, Canada, Japan, Korea and Australia that records increase in their exports. The most affected country is India, where CBAM exports fall by approximately 23% in cumulative terms (2030-2050) compared to the reference scenario (Figure 3). Exports from India to EU27 fall by 15%, while exports to the Rest of the World (ROW) fall by 5%. The second most impacted country, by the implementation of CBAM in the EU27, is Türkiye with overall CBAM exports falling cumulatively by 9%, with export flows to the EU27 accounting for more than 80% of the assessed change. A share of the EU27 market lost by products of Southeast Asian countries and Türkiye is partly taken by goods produced in United Kingdom, USA, Australia, and to a lower extent in Japan and Korea.

In the case of the US, there is a shift of the importer's mix (i.e. countries which export to the US), as Indian and Turkish products are losing market share which shifts to Canada, and S. Korea. While higher exports to India are related to the overall competitiveness losses recorded by the Indian industry. As USA is the most important trade partner of Canada the unilateral adoption of CBAM hinders trade performance of Canadian CBAM related industries. The adoption of carbon adjustment from the US implies benefits for United Kingdom, Australia, and Japan which are projected to increase their exports to the US market and losses for exporters located in China, and India.

With respect to trade changes associated with the introduction of CBAM in Australia, China and Indonesia are mostly affected with exports of CBAM products recording a loss of 0.7% and 1.5% respectively compared to the reference scenario over the projection period (0% in the EUCBAM scenario). The implementation of carbon tariffs in Japan mainly affects goods of Chinese and Indian origin which record cumulative losses of 0.5% and 0.4% respectively (the respective changes in the EUCBAM are 0% and -0.2%).

Moving to the CBAMG2 scenario, where CBAM is also introduced by China, India and Canada, we find that the most important changes are found in China and India, as there are significant bilateral trade flows with high emission content. Chinese and Indonesian exports to India record losses, while exports of (primarily) Japan and South Korea increase by 0.7% and 1.5% with respect to the refence throughout the projection period. The respective change in the CBAMG1 scenario is found to be equal to 0.5% and 1.0%. In China the introduction of CBAM has important implications for Indonesian products as their imports decreases by 1.3% cumulatively compared to a reduction of 0.3% in CBAMG1.





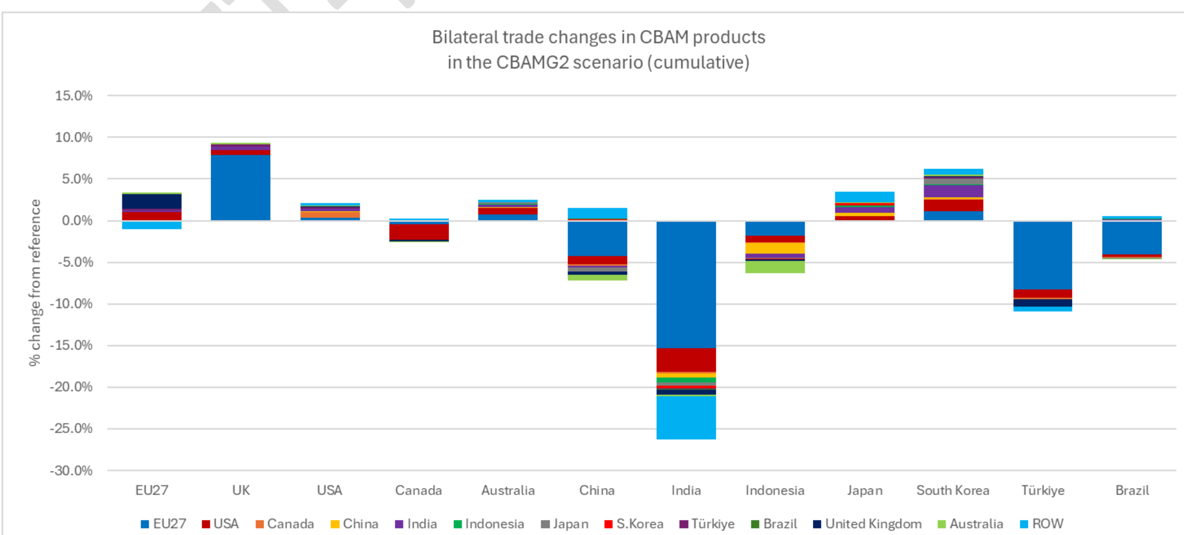


Figure 3: Bilateral trade changes (cumulative) in CBAM products by country (% change from reference)

Conclusions

This study explores the macroeconomic and trade implications of the EU Carbon Border Adjustment Mechanism (CBAM), as well as the potential global expansion of similar policies in major economies. Using the GEM-E3 model, we assessed the macroeconomic and trade impacts of CBAM, providing insights into the evolving landscape of climate-related trade measures.

A first key finding is that CBAM entails only small economy-wide and global impacts. Across all scenarios, changes in global GDP, trade volumes and greenhouse gas emissions remain limited, even when CBAM adoption expands to multiple large economies. This confirms that CBAM does not act as a major macroeconomic shock, but rather as a policy that reshapes relative competitiveness across sectors and countries. The impacts of alternative CBAM adoption rates on GDP are found to be low, with global GDP impacts ranging from 0.02% to 0.07%. In the field of international trade, the adoption of "carbon tariffs" will introduce a new dimension of competitiveness based on carbon content, shifting trade dynamics, as advanced economies continue to move toward lower-emission production methods. In contrast, countries such as China and India, where industrial competitiveness relies heavily on low-cost fossil energy and labor, are likely to face higher adjustment burdens. For example, the adoption of CBAM by Europe, could trigger a shift in trade patterns, with EU imports increasingly sourced from economies with cleaner industrial profiles, such as Japan, South Korea or the US.

Our results highlight that the important economic effects can materialise within countries that implement CBAM, e.g. the EU. While CBAM succeeds in mitigating competitiveness losses and leakage risks for energy-intensive industries, the overall macroeconomic outcome is determined by cost pass-throughs to the rest of the economy. In the EU27, higher prices of carbon-intensive intermediate inputs reduce the competitiveness of manufacturing and service activities not directly covered by CBAM. Increased production costs in energy-intensive sectors can spill over into non-protected sectors, leading to economy-wide competitiveness losses that may cancel out the benefits.

These results suggest that CBAM design and implementation should go beyond protecting energy-intensive sectors and explicitly account for value-chain spillovers. Complementary policies—such as targeted investment support, innovation incentives, and measures to limit downstream cost escalation—are required to preserve competitiveness and employment in non-covered sectors. Without such coordination, the net economic benefits of CBAM for implementing economies may remain limited despite its effectiveness in reducing leakage risks. Further, an expansion of CBAM requires sustained international cooperation. CBAM design should include transparent emissions accounting methods and fair treatment for developing economies, possibly through phased inclusion or adjustment mechanisms. In addition, it would be beneficial for CBAM revenues to be reinvested strategically. This could mean directing funds toward climate mitigation efforts within the EU or other implementing countries, while also allocating part of them to support climate adaptation and decarbonization in the most affected developing countries.

Countries found to be more vulnerable to the implementation of CBAM, particularly those with high emissions intensity and limited domestic carbon pricing, such as India, Türkiye and China, face intensified market disadvantages. Addressing this vulnerability may also require capacity-building partnerships and technical assistance to support alignment with global decarbonization efforts.

To sum up, while CBAM represents an important step towards aligning trade and climate policy, its successful implementation depends on a set of domestic and international measures. These include managing distributional effects within the EU, promoting international policy alignment and ensuring that the mechanism contributes to both emissions reduction and a just transition.

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Author contribution statement

Dimitris Fragkiadakis: Data curation, Formal analysis, Software, Writing – review & editing. **Ioannis Charalampidis:** Formal analysis, Software, Writing – original draft. **Zoi Vrontisi:** Conceptualization, Methodology, Project administration, Supervision, Validation, Writing – review & editing. **Eleni-Christina Gkampoura:** Writing – original draft, Visualization.

References

1. Kuik, O., & Hofkes, M. (2010). Border adjustment for European emissions trading: Competitiveness and carbon leakage. *Energy Policy*, 38(4), 1741–1748. https://doi.org/10.1016/j.enpol.2009.11.048
2. Böhringer, C., Balistreri, E. J., & Rutherford, T. F. (2012). The role of border carbon adjustment in unilateral climate policy: Overview of an Energy Modeling Forum study (EMF 29). *Energy Economics*, 34(SUPPL.2). https://doi.org/10.1016/j.eneco.2012.10.003
3. Böhringer, C., Carbone, J. C., & Rutherford, T. F. (2012). Unilateral climate policy design: Efficiency and equity implications of alternative instruments to reduce

carbon leakage. *Energy Economics*, 34(SUPPL.2). https://doi.org/10.1016/j.eneco.2012.09.011

4. Fischer, C., & Fox, A. K. (2011). Comparing policies to combat emissions leakage: Border carbon adjustments versus rebates. *Journal of Environmental Economics and Management*, 64(2), 199–216. https://doi.org/10.1016/j.jeem.2012.01.005
5. Takeda, S., & Arimura, T. H. (2024). A computable general equilibrium analysis of the EU CBAM for the Japanese economy. *Japan and the World Economy*, 70. https://doi.org/10.1016/j.japwor.2024.101242
6. Chu, H. L., Do, N. T., Nguyen, L., Le, L., Ho, Q. A., Dang, K., & Ta, M. A. (2024a). The economic impacts of the European Union's Carbon Border Adjustment Mechanism on developing countries: the case of Vietnam. *Fulbright Review of Economics and Policy*, 4(1), 1–17. https://doi.org/10.1108/frep-03-2024-0011
7. Clora, F., Yu, W., & Corong, E. (2023). Alternative carbon border adjustment mechanisms in the European Union and international responses: Aggregate and within-coalition results. *Energy Policy*, 174. https://doi.org/10.1016/j.enpol.2023.113454
8. European Commission. (2022). Impact assessment report Accompanying the document Proposal for a regulation of the European Parliament and of the Council establishing a carbon border adjustment mechanism. Staff Working Document, SWD (2021) 643 final.
9. Gu, R., Guo, J., Huang, Y., & Wu, X. (2023). Impact of the EU carbon border adjustment mechanism on economic growth and resources supply in the BASIC countries. *Resources Policy*, 85. https://doi.org/10.1016/j.resourpol.2023.104034
10. Ramadhani, D. P., & Koo, Y. (2022). Comparative analysis of carbon border tax adjustment and domestic carbon tax under general equilibrium model: Focusing on the Indonesian economy. *Journal of Cleaner Production*, 377. https://doi.org/10.1016/j.jclepro.2022.134288
11. Acar, S., Aşıcı, A. A., & Yeldan, A. E. (2022). Potential effects of the EU's carbon border adjustment mechanism on the Turkish economy. *Environment, Development and Sustainability*, 24(6), 8162–8194. https://doi.org/10.1007/s10668-021-01779-1
12. Jebeli, H., Chen, Y. H. H., Johnston, C., Paltsev, S., & Tremblay, M. C. (2025). Impacts of border carbon adjustments on the Canadian economy. *Energy Economics*, 141. https://doi.org/10.1016/j.eneco.2024.108089
13. Beaufils, T., Ward, H., Jakob, M., & Wenz, L. (2023). Assessing different European Carbon Border Adjustment Mechanism implementations and their impact on trade partners. *Communications Earth & Environment*, 4(1), 131.
14. He, X., Zhai, F., & Ma, J. (2025). Global Impact of the Carbon Border Adjustment Mechanism–A Quantitative Assessment. *Journal of Globalization and Development*.
15. Chen, G. (2023). Impact of carbon border adjustment mechanism on China's manufacturing sector: a dynamic recursive CGE model based on an evolutionary game. *Journal of Environmental Management*, 347, 119029.

16. Bye, B., Kaushal, K. R., & Storrøsten, H. B. (2025). EU's carbon border adjustment mechanism CBAM–industrial effects. *Climate Policy*, 1-13.
17. Yan, L., Weng, K., Zhou, H., Zhu, D., Zhu, X., Zhou, Y., ... & Du, Z. (2025). The Long-Term Impact of Carbon Border Adjustment Mechanism on China's Power Supply and Demand and Environmental Benefits: An Analysis Based on the Computable General Equilibrium Model. *Energies*, 18(18), 4943.
18. Ren, L., Wang, J., Zhang, L., Hu, X., Ning, Y., Cong, J., ... & Shi, X. (2025). Quantitative Assessment of the Carbon Border Adjustment Mechanism: Impacts on China–EU Trade and Provincial-Level Vulnerabilities. *Sustainability*, 17(4), 1699.
19. Delgado-Téllez, M., Quintana, J., & Santabárbara, D. (2025). Carbon pricing, border adjustment and renewable energy investment: a network approach. Banco de Espana Working Paper No. 2506
20. Bellora, C., & Fontagné, L. (2022). EU in search of a WTO-compatible carbon border adjustment mechanism.
21. Tsakiris, N., & Vlassis, N. (2024). Border carbon adjustments and leakage in the presence of public pollution abatement activities. *Environmental and Resource Economics*, 87(9), 2231-2258.
22. Amendola, M. (2025). Winners and losers of the EU carbon border adjustment mechanism. An intra-EU issue?. *Energy Economics*, 142, 108139.

Appendix 1 - Trade status and global production in selected energy intensive industries

Table 3: Global export market shares by country and by CBAM sector (COMTRADE)

	Cement	Iron & Steel	Aluminium	Fertilizers
United Kingdom	0.48%	1.28%	1%	0.68%
Türkiye	11.50%	2.23%	2.64%	0.76%
USA	1.68%	3.81%	5.12%	8.28%
Canada	4.78%	1.94%	6.90%	14.52%
China	2.43%	18.02%	13.18%	14.77%
India	0.38%	3.06%	4.05%	0.16%
Indonesia	0.38%	3.06%	4.05%	0.16%
South Korea	0.90%	6.01%	2.41%	0.65%
Japan	2.35%	6.51%	0.97%	0.18%
Australia	0.03%	0.16%	2.41%	0.34%

Table 4: Iron and Steel: Bilateral exports by country – COMTRADE data for 2023 in million $

	Australia	Brazil	Canada	China	India	Indonesia	Japan	Rep. of Korea	Türkiye	United Kingdom	USA	EU27	Total
Australia	0	0	19	6	17	25	1	4	3	7	247	99	774
Brazil	6	0	331	1368	68	22	361	227	160	130	7120	2113	15567
Canada	17	14	0	39	30	2	3	12	3	9	8906	153	9570
China	864	2579	958	0	3750	4005	1790	7117	3552	335	1778	5453	88656
India	150	196	227	564	0	402	196	464	565	393	1263	4946	15070
Indonesia	200	24	18	18342	1648	0	34	355	447	52	164	649	27561
Japan	184	270	213	3560	1389	2256	0	4394	598	138	2155	1942	32017
Rep. of Korea	347	289	624	2703	2533	976	3354	0	1654	285	3706	4124	29580
Türkiye	63	48	281	5	22	2	45	13	0	295	378	3624	10992
United Kingdom	26	89	75	92	62	9	23	35	266	0	490	4086	6318
USA	95	217	7434	391	153	12	146	160	101	254	0	1330	18724
EU27	305	1351	1311	2188	1135	508	250	617	3615	5616	8473	0	169590

Table 5: Aluminum: Bilateral exports by country – COMTRADE data for 2023 in bn.$

	Australia	Brazil	Canada	China	India	Indonesia	Japan	Rep. of Korea	Türkiye	United Kingdom	USA	EU27	Total
Australia	0	2	17	62	40	104	802	1147	0	2	306	118	3502

Brazil	0	0	1	2	0	0	362	1	0	0	133	308	1184
Canada	0	1	0	11	4	0	0	1	1	8	9417	300	10039
China	647	292	657	0	986	518	979	1586	258	311	894	1143	19159
India	22	104	29	222	0	48	402	816	188	53	380	810	5884
Indonesia	43	0	14	228	16	0	10	11	59	9	114	28	695
Japan	5	6	4	553	11	39	0	98	1	5	176	130	1417
Rep. of Korea	108	4	9	862	158	78	208	0	124	1	538	305	3508
Türkiye	0	2	61	6	1	0	0	0	0	174	275	2441	3832
United Kingdom	7	5	6	19	34	3	11	13	15	0	112	1056	1458
USA	22	55	2073	127	51	9	243	234	66	125	0	341	7441
EU27	60	205	223	319	146	25	169	168	647	2426	1598	0	46212

Table 6: Fertilizers: Bilateral exports by country – COMTRADE data for 2023 in bn.$

	Australia	Brazil	Canada	China	India	Indonesia	Japan	Rep. of Korea	Türkiye	United Kingdom	USA	EU27	Total
Australia	0	0	1	1	1	0	2	0	0	1	25	2	204
Brazil	0	0	0	0	0	0	0	0	0	0	2	1	181
Canada	5	391	0	390	277	243	1	1	0	1	2737	46	4509
China	351	486	6	0	1015	450	205	231	64	2	104	47	6006
India	0	0	0	0	0	2	0	0	0	0	0	5	77
Indonesia	25	8	5	0	41	0	2	7	0	1	0	0	280
Japan	1	0	1	8	1	1	0	14	0	0	20	12	115
Rep. of Korea	16	0	0	1	15	10	37	0	13	0	1	8	330
Türkiye	0	0	0	0	0	0	0	1	0	1	0	58	195
United Kingdom	1	37	2	14	3	0	0	0	2	0	6	145	237
USA	221	814	998	102	178	5	170	111	14	10	0	121	3728
EU27	50	520	73	184	50	91	18	14	151	580	158	0	9847

Table 7: Cement: Bilateral exports by country – COMTRADE data for 2023 in bn.$

	Australia	Brazil	Canada	China	India	Indonesia	Japan	Rep. of Korea	Türkiye	United Kingdom	USA	EU27	Total
Australia	0	0	0	0	0	0	0	0	0	0	0	0	3
Brazil	0	0	0	0	0	0	0	0	0	0	0	0	11
Canada	0	0	0	0	0	0	0	0	0	1	441	1	444
China	25	1	1	0	5	1	10	9	1	1	95	8	578
India	0	0	0	0	0	0	0	0	0	0	0	1	271
Indonesia	21	0	0	0	0	0	0	0	0	0	0	0	129
Japan	63	0	0	2	5	0	0	26	0	0	1	5	359
Rep. of Korea	0	0	0	0	0	0	11	0	0	0	24	0	106

Türkiye	0	11	9	0	0	0	0	0	0	2	67	80	596
United Kingdom	1	1	0	2	0	0	2	0	0	0	2	50	66
USA	1	0	147	2	0	0	2	2	0	1	0	8	202
EU27	4	8	12	1	1	0	2	1	3	280	225	0	2823

Appendix 2 - The GEM-E3 Model and Scenario Design

Table 8: Regional resolution of the GEM-E3 model

Country Code:	Description:	Country Code:	Description:
AUT	Austria	**USA**	USA
BEL	Belgium	**JPN**	Japan
BGR	Bulgaria	**CAN**	Canada
CYP	Cyprus	**BRA**	Brazil
CRO	Croatia	**CHN**	China
CZE	Czech Republic	**IND**	India
DEU	Germany	**KOR**	South Korea
DNK	Denmark	**IDN**	**Indonesia**
ESP	Spain	**MEX**	Mexico
EST	Estonia	**ARG**	Argentina
FIN	Finland	**TUR**	Türkiye
FRA	France	**SAR**	Saudi Arabia
GBR	United Kingdom	**OCE**	Oceania
GRC	Greece	**RUS**	Russian federation
HUN	Hungary	**ARE**	United Arab Emirates
IRL	Ireland	**REP**	Rest of energy producing countries
ITA	Italy	**SAF**	South Africa
LTU	Lithuania	**REU**	Rest of Europe
LUX	Luxembourg	**ROW**	Rest of the World
LVA	Latvia		
MLT	Malta		
NLD	Netherlands		
POL	Poland		
PRT	Portugal		
SVK	Slovakia		
SVN	Slovenia		
SWE	Sweden		
ROU	Romania		

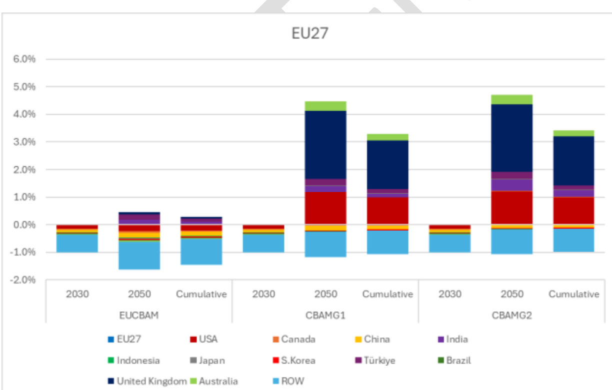
Table 9: Sectoral resolution of the GEM-E3 model

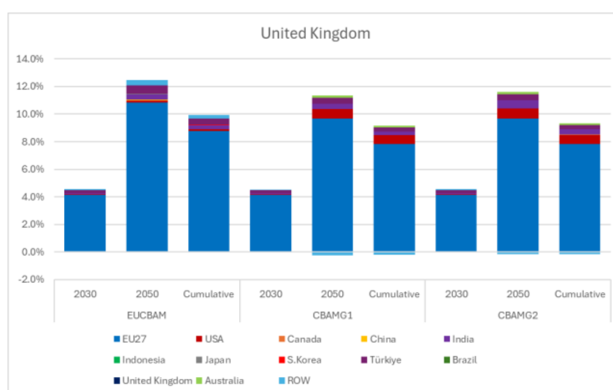
Code	Description	Code	Description	Code	Description
Industry		**Industry (continued)**		**Agriculture**	
IND01	Ferrous metals	**IND19**	Equipment for PV panels	**AGR01**	Agriculture
IND02	Non-ferrous metals	**IND20**	Equipment for CCS power technology	**Services**	
IND03	Fabricated Metal products	**IND21**	CO_2 Capture	**SRV01**	Market Services
IND04	Chemical Products	**Energy**		**SRV02**	Non Market Services
IND05	Basic pharmaceutical products	**ENE01**	Coal	**SRV03**	R&D
IND06	Rubber and plastic products	**ENE02**	Crude Oil	**Power Generation**	
IND07	Paper products, publishing	**ENE03**	Oil	**PGT01**	Coal fired
IND08	Non-metallic minerals	**ENE04**	Gas	**PGT02**	Oil fired
IND09	Computer, electronic and optical products	**ENE05**	Power Supply	**PGT03**	Gas fired
IND10	Other Equipment Goods	**ENE06**	Biomass Solid	**PGT04**	Nuclear
IND11	Transport equipment (excluding EV)	**ENE07**	Biofuels	**PGT05**	Biomass
IND12	Consumer Goods Industries	**ENE08**	Hydrogen	**PGT06**	Hydro electric
IND13	Construction	**ENE09**	Clean Gas	**PGT07**	Wind
IND14	Batteries	**Transport**		**PGT08**	PV
IND15	EV Transport Equipment	**TRA01**	Warehousing and support activities	**PGT09**	Geothermal
IND16	Advanced Electric Appliances	**TRA02**	Air transport	**PGT10**	CCS coal
IND17	Advanced Heating and Cooking Appliances	**TRA03**	Land transport	**PGT11**	CCS Gas
IND18	Equipment for wind power technology	**TRA04**	Water transport	**PGT12**	CCS Bio

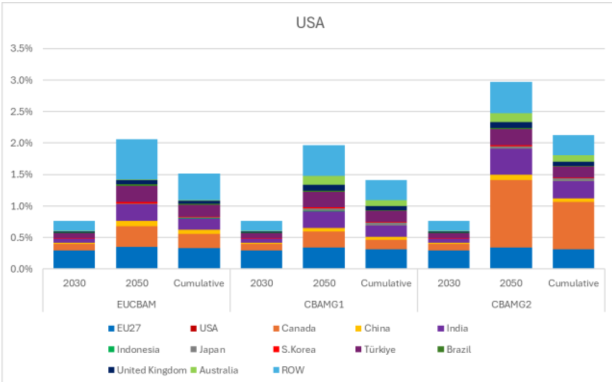
Table 10: Energy intensity relative to EU27

	Aluminum	Cement	Fertilizers	Iron and steel	Electricity
China	3.37	1.64	2.39	3.22	5.63
India	3.96	1.43	2.82	12.50	3.23
Indonesia	8.29	1.46	1.26	2.70	6.97
Japan	0.70	0.94	0.91	0.78	1.57
Korea, Rep.	0.48	0.99	0.94	1.13	2.74
Australia	4.23	0.91	1.11	1.03	3.00
Türkiye	0.95	0.98	1.30	1.66	2.43
United States	0.94	1.08	0.81	1.27	3.21
Canada	1.27	1.15	1.12	2.38	1.20
Brazil	8.06	0.99	0.50	2.32	0.76
United Kingdom	0.22	0.95	0.53	0.77	1.23

Appendix 3 - Bilateral trade changes in CBAM products by country



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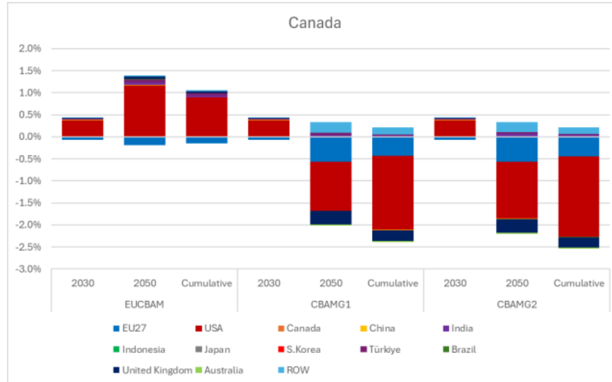
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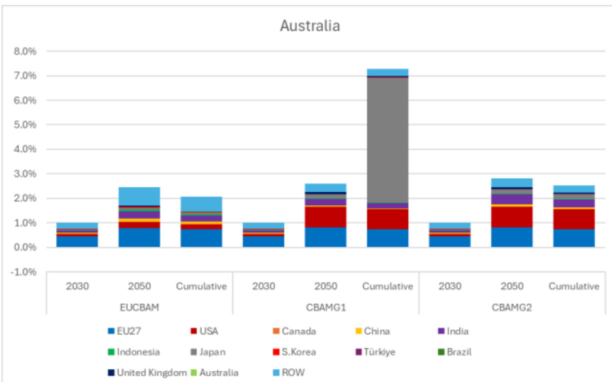
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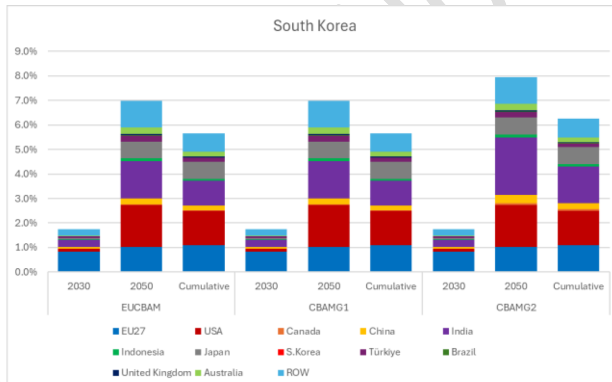
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Australia
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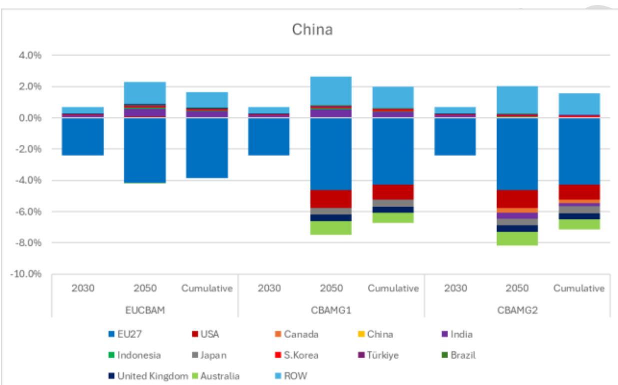
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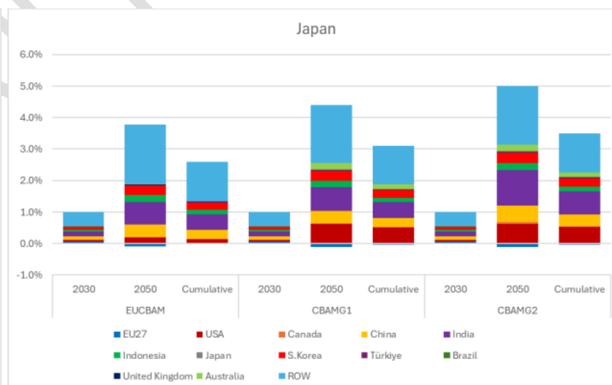
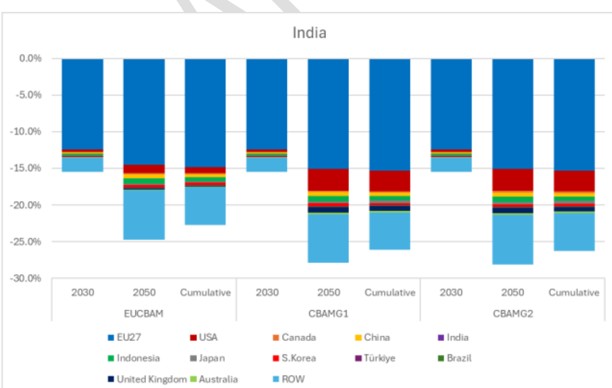
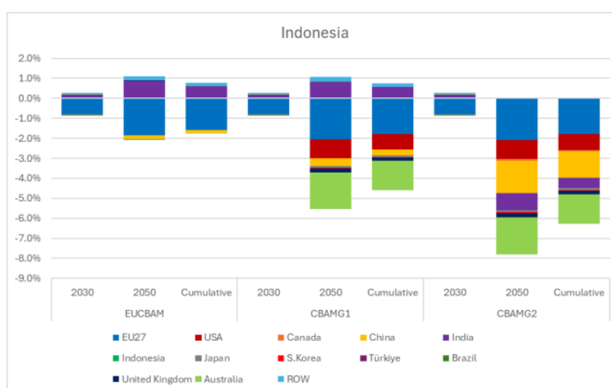
Australia
ROW


Japan
6.0%
5.0%
4.0%
3.0%
2.0%
1.0%
0.0%
-1.0%
2030
2050
Cumulative
EUCBAM
CBAMG1
CBAMG2
EU27
USA
Canada
China
India
Indonesia
Japan
S.Korea
Türkiye
Brazil
United Kingdom
Australia
ROW


India
0.0%
-5.0%
-10.0%
-15.0%
-20.0%
-25.0%
-30.0%
2030
2050
Cumulative
EUCBAM
CBAMG1
CBAMG2
EU27
USA
Canada
China
India
Indonesia
Japan
S.Korea
Türkiye
Brazil
United Kingdom
Australia
ROW


Indonesia
2.0%
1.0%
0.0%
-1.0%
-2.0%
-3.0%
-4.0%
-5.0%
-6.0%
-7.0%
-8.0%
-9.0%
2030
2050
Cumulative
EUCBAM
CBAMG1
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Brazil
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Australia
ROW

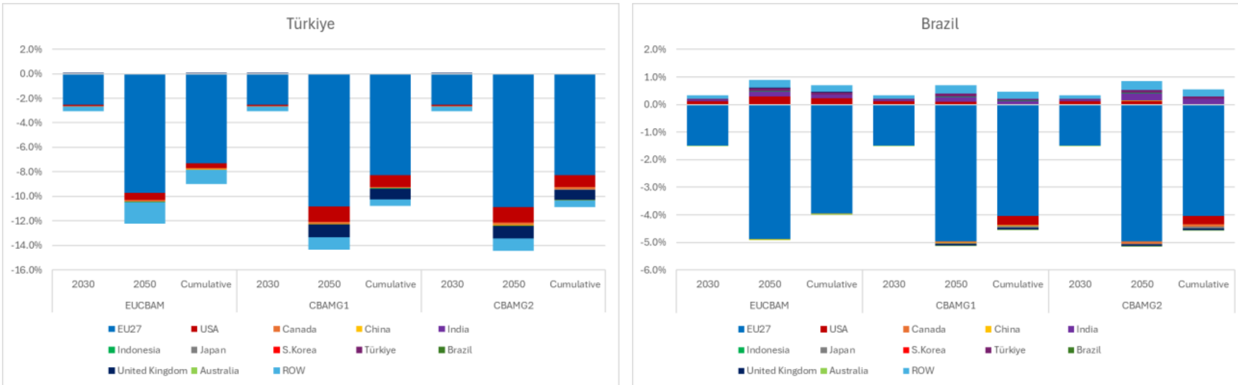

Figure 4: Bilateral trade changes in CBAM products by country (% change from reference)