The EU-India Free Trade Agreement: Ex-Ante Trade, CO2 Emission, and Welfare Effects under the Carbon Border Adjustment Mechanism

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Abstract

Gains from trade liberalization are accompanied by environmental externalities of increased greenhouse gas emissions. The EU is currently active on both trade and climate policy frontiers. By means of a new quantitative trade model, this study uncovers counterfactual changes in trade, CO2 emissions, and welfare of an EU-India FTA, first as a standalone policy, and then, in conjunction with a Carbon Border Adjustment Mechanism (CBAM). Trade data from the OECD Inter-Country Input-Output (ICIO) tables and CO2 emission data from the OECD Trade in Embodied CO2 (TECO2) database are used. While CBAM decreases trade volumes and CO2 emissions, a hypothetical EU-India FTA results in significant increases in both trade and CO2 emissions, on average. The interplay of CBAM and the FTA feature adverse trade and CO2 emission effects for India. The burden of CO2 emission mitigation efforts is unequally distributed. When considering the Armington assumption of national product differentiation and no intermediate goods, welfare effects are found to be negative for India.

Keywords: climate change, international trade, Free Trade Agreement, carbon leakage, Carbon Border Adjustment Mechanism, EU, India

JEL Classification: F140, F170, F180

Acknowledgements: First and foremost, I would like to thank my master's thesis supervisor Ruben Dewitte for his excellent guidance and helpful tips along several stages of this paper. I thank Joschka Wanner, Jan Brusselaers, as well as the conference participants at the EENR Conference 2024 in Orléans and the EGEI Seminar in Lille for generous comments. All errors are my own.

1 Introduction

Gains from trade liberalization are accompanied by negative environmental externalities of increased greenhouse gas emissions. Over two thirds of global CO2 emissions linked to production are traded (Copeland (2021)). The EU is currently active on both trade and climate policy frontiers: while on the one hand, the EU searches new trading partners given a reinforced potential for geoeconomic conflicts, on the other hand, it claims itself the front runner of greenhouse gas emission mitigation efforts.

In the quest for an answer to the negative externality resulting from a "tragedy of the commons" of unilateral climate policy efforts (Bellora and Fontagné (2022)), the idea of a climate club advocated by Nordhaus (2015), and recently Bierbrauer et al. (2021) remains an important consideration. Similar to free trade areas, the idea is to gather like-minded countries as a club of cooperating parties who exempt each other from the application of a CO2 limit while sanctioning unwilling parties by means of CO2 border taxes. As a club of EU countries jointly determined to tackle the global negative externality from CO2 emissions, CBAM is intended to make the first move as a stepping stone towards larger climate clubs and, eventually, multilateral climate policy.

Research on the interlinkage between trade and the environment is trending. Several studies have assessed border carbon adjustment as a potential way to internalize negative externalities from CO2 emissions through import tariffs (Cosbey et al. (2019), Dröge (2021), Böhringer et al. (2022)). Existing ex-ante impact assessments on the EU carbon border adjustment mechanism either focus on country aggregates (Mörsdorf (2022), (Bellora and Fontagné (2022), Korpar et al. (2023)) or on single countries such as India (Simola (2021)). While the unilateral CBAM as a pro-environment policy has recently been implemented, an EU-India Free Trade Agreement (FTA) is currently being discussed. Prior ex-ante studies (Felbermayr et al. (2017), Gallina et al. (2020)) show that under an EU-India FTA, Indian exports of emission-intensive and traded goods (EITE), such as basic metals or chemicals, would increase. Several tariff lines pertaining to these industries are under current CBAM legislation.

Despite far-reaching consequences for trade and the environment, an ex-ante impact assessment of the interplay of "pro-trade" policies and "pro-environmental" policies is missing. This study proposes a novel approach to introduce carbon emissions into an otherwise standard ex-ante FTA impact assessment. This allows to analyse the effectiveness of climate policies given the EU's current trade liberalization agenda and vice-versa. Understanding the EU-India FTA and CBAM as representatives of two current "pro-trade" and "pro-environmental" policies, this study provides insights on the interplay between trade and CO2 emissions. While CBAM decreases trade volumes and CO2 emissions, a hypothetical EU-India FTA would result in significant increases in both trade and CO2 emissions. The study finds that via CBAM, the EU sets a comparative advantage vis-à-vis India regarding the export of products subject to CBAM, especially under a potential EU-India FTA. Moreover, it is found that the burden of CO2 emission mitigation is unequally distributed in case of an EU-India FTA. While the welfare effects of the EU-India FTA alone are found to be positive for the EU on average, India would incur a welfare loss. The finding on negative welfare for India may ignite a discussion on optimal tariff levels (Gros (1987), Costinot and Rodríguez-Clare (2014)), especially so in the context of environmental policy goals, and potential limitations of the model (e.g., Balistreri and Rutherford (2012)).

Related Literature

The brief literature review sets out with the political economy of CBAM in India and ex-ante welfare effects of CBAM on the Indian economy. A review of EU-India tariff policy and trade and welfare effects found in the two most recent ex-ante studies on the EU-India FTA follows.

From EU ETS to CBAM. The European Green Deal sets the overall tune to make the EU carbon neutral by 2050. Under the "Fit for 55" strategy, the EU envisages a greenhouse gas (GHG) emission reduction by 55% (1990 vs. 2030). To make headway on this road, in 2005, the EU launched the Emissions Trading System (EU ETS), the world's first carbon market. The EU ETS works on the "cap and trade" principle. A cap is set on the total amount CO2 equivalents (CO2e) that can be emitted by participating firms - the so-called allowances. These allowances can either be auctioned or be granted to firms for free. Firms can trade allowances among each other on the EU ETS carbon market (Dröge (2021), Ambec (2022)). The Carbon Border Adjustment Mechanism (CBAM) is linked to the free allowances' gradual phase-out. The implications of allowances for trade and the environment can be imagined as follows. Since a cap on allowed CO2e raises the price of production technologies, the concept of allowances can be transferred to the principle of a carbon price, with potential implications on competitiveness. The EU ETS allowances then have two potentially ambiguous effects: on the one hand, they might trigger a green transition toward less carbon-intensive production technologies, an intended "environmental steering effect." But on the other hand, through altering the relative prices between countries and sectors, carbon pricing in the form of allowances might impact relative competitiveness, resulting in a worse terms-of-trade vis-à-vis competitors (Dechezleprêtre and Sato (2017), Table 1, p. 186). One of the forms of the latter is often phrased as "carbon leakage", meaning the relocation of production to less strictly regulated jurisdictions abroad, and feared by EU producers, lobbies and policymakers (Cosbey et al. (2019), Bellora and Fontagné (2022)). Nonetheless, the EU has been pushing forward environmental steering by tightening the ETS. This means that the ceiling of permitted CO2 equivalents is descending over time, thereby reducing free allowances, until they are projected to have been phased out entirely by 2030 (Dröge (2021), Bellora and Fontagné (2022), Overland and Sabyrbekov (2022)). A policy that reconciles the "Fit for 55" goal with competitiveness, the EU has created the CBAM as a tool to safeguard that the unilateral CO2 achievements by the EU are not counteracted by competitiveness losses accompanied by CO2 emission leakage elsewhere. After a three-year phase-in period that started in October 2023, the CBAM will become fully operational starting 2026. For each good whose tariff line pertains to the CBAM list, the exporting firm is to declare the total quantity and the total direct embedded CO2 emissions as well as the total number of CBAM certificates corresponding to the total embedded emissions.

Ex-ante Assessments of CBAM and the EU-India FTA. To track changes in trade flows and output under CBAM, Bellora and Fontagné (2022) employ an ex-ante dynamic general equilibrium model of the world economy. They model the gradual phase-out of free allowances in parallel to the introduction of the CBAM by discounting the bilateral carbon price differentials with the share of free allowances and compare a CBAM that differs with respect to compliance with WTO rules. In all scenarios, CBAM applies to all products under the EU ETS. Using the multi-region, multi-sector structural gravity model of Larch and Wanner (2017), Korpar et al. (2023) estimate the effects of CBAM on exports, real GDP, welfare, and CO2 emissions for 43 countries and 14 sectors. They assume prevailing CO2 prices in each country, sector-specific average emission intensities of partner countries and, by and large, the five sectors as in the EU Commission's CBAM proposal. The CBAM is modeled using by backing out the bilateral carbon price differential from the price of a ton of CO2 emissions in each country, while considering the gradual phase-out of free allowances granted within the EU ETS.

Felbermayr et al. (2017)'s ex-ante assessment of the EU-India FTA comes in between the halt of the first negotiation round (2007-2013) and the launch of the second series (2022). Using the GTAP 9 database to calibrate trade and tariff data from 140 countries and regions and 57 goods and services sectors for 2011 to the CGE "ifo Trade Model" (Aichele et al. (2016)), the authors quantify the effects of hypothetical EU-India FTA policy scenarios on sectoral trade flows, tariff revenues, and GDP. The first scenario foresees a "shallow" complete tariff elimination, first, for manufacturing only and then, for all goods. Their third "deep" scenario accounts for the reduction of non-tariff barriers (NTMs). Gallina et al. (2020) employ a new quantitative trade model (NQTM) to simulate the impact of the potential trade agreement between the EU and India. For their baseline equilibrium as of 2014, the authors take bilateral trade flows from the World Input-Output Database (Timmer et al. (2015)) including 42 countries and 24 sectors aggregated according to the ISIC Rev. 4 classification. This study adopts their model that accounts for government tariff revenue changes as a rent-creating tariff barrier and takes over the assumption regarding the tariff reduction, Scenario 1c.

Both Felbermayr et al. (2017) and Gallina et al. (2020) abstract from accounting for CO2 emissions. Regarding the incorporation of environmental policy to the EU-India FTA, Gallina et al. (2020) assert difficulties of quantifying the impact of an EU-India FTA in terms of its environmental dimensions. They however argue that a hypothetical FTA should consider the negative externalities from carbon emissions embodied in trade flows, claiming international collaboration on this matter to be particularly relevant.

This study. Adding to the literature, this study brings CO2 emissions into the analysis and examines the impact of the FTA on the environment and potential changes in sectoral competitiveness due to CBAM. The scope of this paper is then to first quantify trade and CO2 emissions gains from a hypothetical "pro-trade" policy against losses under the CBAM as a "pro-environmental" policy in order to mirror them against each other. Moreover, this exercise serves to enrich the literature pertaining to the political economy of trade and environmental policy in India.

2 Descriptive Data Analysis

2.1 Data Sources

The data used for the counterfactual model simulation stem from the following sources: trade data from the OECD Inter-Country Input-Output (ICIO) tables (OECD (2022b)) and CO2 emission data from the OECD Trade in Embodied CO2 (TECO2) database (OECD (2022c)) are used. The ICIO tables capture worldwide trade flows between country-industry pairs, e.g., the value of exports in the basic metals industry aggregate from India to the EU in 2014, measured in current USD. The CO2 emission intensity in tons of CO2 per USD of gross output of each country-sector pair is obtained by dividing CO2 emissions by gross output at basic prices. Business-as-usual (BAU) tariffs are sourced from the UN TRAINS database (UN (2023)). The EU-India FTA tariff liberalisation scenarios stem from Gallina et al. (2020). Sector-level trade elasticities are adopted following Caliendo and Parro (2015) and are similar to Gallina et al., 2020. The base year of the model simulations is 2014.

2.2 Descriptive Data Analysis

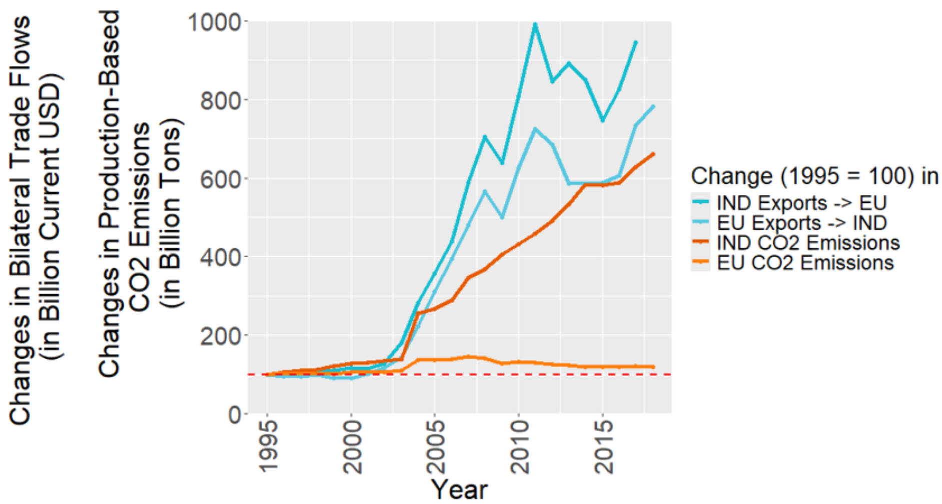

Fig. 1 The Evolution of Gross Bilateral Trade and CO2 Emissions Embodied in Production between the EU and India, 1995-2018.

Figure 1 confirms the sustained increase in goods and services trade between the EU and India from 1995 until 2018 discussed (Gallina et al. (2020), Felbermayr et al. (2017)). Alongside rising trade values, CO2 emissions embodied in exports from India to the EU increased sixfold.

Although the EU-India trade pattern has seen substantial tariff reductions vis-à-vis the tariff level of the 1990s, there remain some barriers to trade. While the EU's MFN tariffs in the food and beverages industry (5) are about 10% per HS 6-digit code, tariffs in the basic metals industry (14) are about 2.5%. As the left panel of Figure 2 shows, the EU's import tariffs to India are substantially lower on dirty than on clean industries. With the exception of chemicals (10) this applies to all other industry aggregates to which CBAM applies, namely fabricated metal products (15), basic metals (14), and other non-metallic mineral products (13). This finding on a "pollution subsidy" is in line with Shapiro, Joseph S (2021).

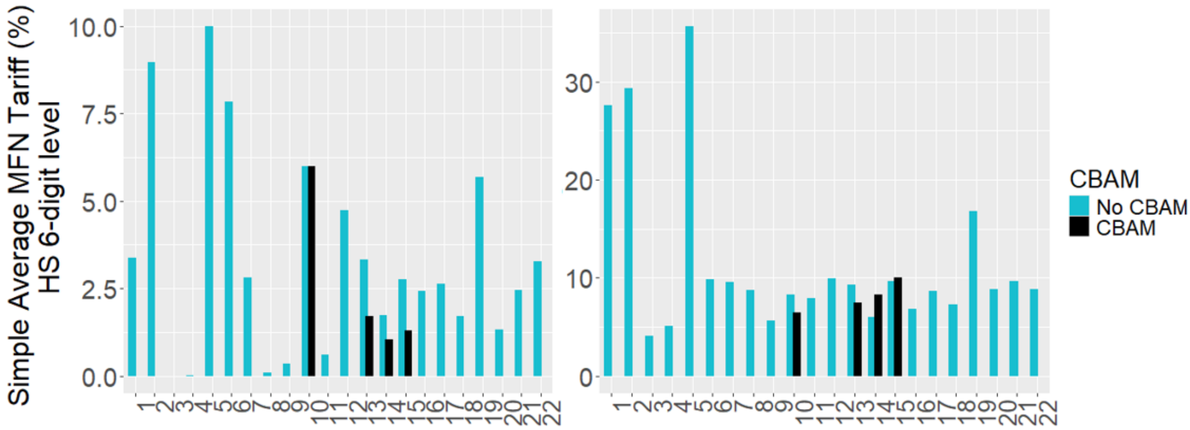

Fig. 2 Simple Average MFN Tariff Rates Vis-à-Vis the Rest of the World at the HS 6-digit Level. *Left*: EU, *Right*: India. Per Industry Aggregate, 2014.

The right panel of Figure 2 display's India's average MFN tariffs as of 2014. India's bold trade liberalisation agenda in the 1990s marked the end of India's decade-long protectionist trade policy. After the WTO Uruguay Round and in subsequent unilateral liberalization steps, India substantially reduced its mean applied tariff rate (Gaurav and Mathur (2016)). On the other hand, compared to the world average, India still maintains relatively high tariff barriers (Khorana and Garcia (2013), Felbermayr et al. (2017)). In 2019, several Indian industries, including crops and animals (1), fishing and agriculture (2), food, beverage and tobacco (5), and motor vehicles (19), were found to be protected with applied tariff averages of at least 15% (Gallina et al. (2020)).

The first round of negotiations on the EU-India Free Trade Agreement has started in 2007. After six years of negotiations, the parties have not found common grounds, such that the talks were halted. In June 2022, in the context of the EU's geopolitical 'strategic autonomy', negotiations were re-launched and are in full swing. After a failed first free trade agreement (FTA) negotiation round, it appears questionable whether the EU can afford a halt of negotiations on an FTA given the current geoeconomic tensions[1].

[1] Examples are Covid-19, wars (Russian war in Ukraine) or critical dependencies from rising hegemons (China).

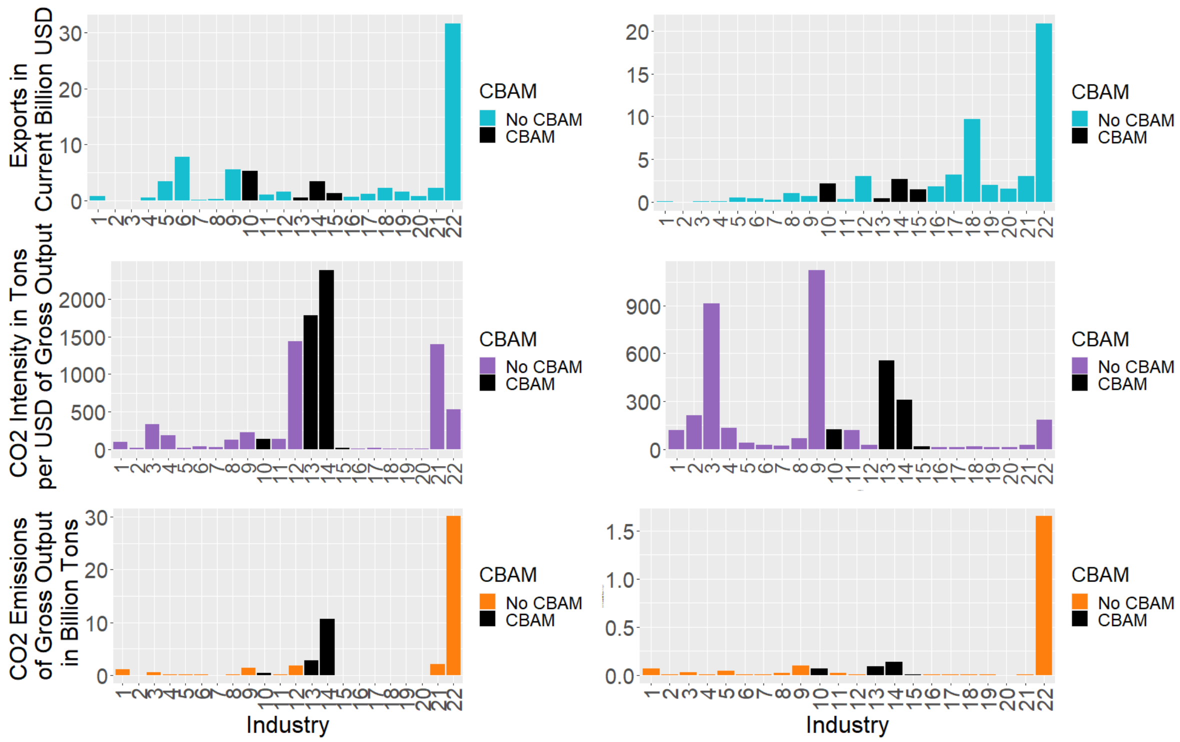

Fig. 3 **Left**: India's Exports to the EU, CO2 Emission Intensity of Production, and CO2 Emissions in Production. **Right**: EU's Exports to India, CO2 Emission Intensity of Production, and CO2 Emissions in Production. Per Industry Aggregate, 2014.

Figure 3 presents bilateral exports, CO2 intensities, and production-based CO2 emissions for each industry in India (left) and the EU (right), in 2014. A black bar indicates that an industry aggregate contains tariff lines (HS6 6-digits) which are included in the EU Commission's CBAM proposal. Although India's exports to the EU in basic metals (14) rank fourth in terms of goods export volume, the sector has the highest CO2 intensity and overall CO2 emissions compared to all other industries in India.

3 Research Questions, Methodology, and Policy Scenarios

3.1 Research Questions

The research questions rest on the following thought experiment: how would trade, CO2 emissions and real income look like in 2024, if the EU and India moved from the baseline equilibrium (2014) to a hypothetical equilibrium with changes in trade costs? In concrete, the research questions concern the effects of changes in bilateral import tariff rates between the EU and India on

1. trade flows in current (free-on-board) USD
2. CO2 emissions in million tons, and
3. welfare as a percentage change of real income

either in goods tackled by the CBAM and goods not tackled by the CBAM.

3.2 Policy Scenarios

The EU-India FTA and the EU CBAM as "pro-trade" and "pro-environmental" policies are modelled with three different tariff change scenarios applying to the EU and India.

Originating from a business-as-usual (BAU) baseline equilibrium, the following three different policy scenarios for changes in bilateral tariffs are fed into the model:

1. from BAU to CBAM (BAU-CBAM)
2. from BAU to the EU-India FTA (BAU-FTA)
3. from CBAM to the EU-India FTA (CBAM-FTA).

Policy scenario 1, BAU-CBAM, models the phase-in of an EU CBAM, as currently implemented. The second scenario, BAU-FTA, models an EU-India FTA as a standalone policy, regardless of the CBAM. The BAU-FTA scenario can then be compared to scenario 3, CBAM-FTA, which models the trade, CO2 emission and welfare effects of a hypothetical EU-India FTA if CBAM tariffs of the EU to its non-EU trading partners are already in place. Since CBAM has been launched in October 2023 and the EU-India FTA negotiations are still ongoing, this latter scenario is the most likely one.

The construction of the bilateral tariffs at the country-sector level is described in Appendix B.1. Exemplary for exports of basic metals (14) from India to the EU, Table B.1 shows the bilateral tariff structure assumed for BAU and all three policy scenarios.

3.3 Hypotheses

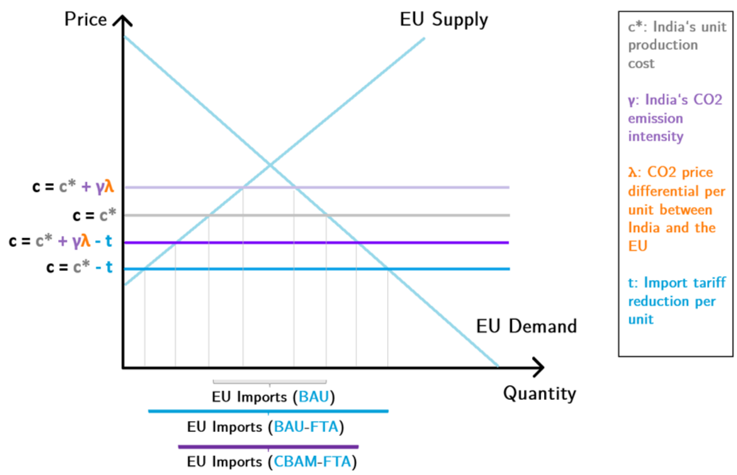

Fig. 4 EU-India FTA and CBAM: Stylized Potential Changes of Trade Flows Between the Business-as-Usual (BAU) Equilibrium and Two Counterfactual Equilibria (BAU-FTA and CBAM-FTA).

By plotting supply and demand of a CBAM industry good in an EU country, Figure 4 illustrates the comparative statics of potential trade effects linked to the policy scenarios. The import value in the BAU equilibrium hinges upon the relative production costs $c/c*$ of the EU and India, marked by an asterisk. While a reduction of the EU's import tariff by $-t$ might have a positive influence on exports from India, a CBAM tariff, modeled as the product of India's emission intensity γ and the carbon price differential between India and the EU λ, might lead to a contraction in exports vis-à-vis the baseline equilibrium or offset the gains from an FTA, to some extent.

3.3.1 Trade and CO2 Emissions

Due to higher import tariffs to several CBAM industries, in the CBAM standalone scenario, exports from India to the EU are expected to fall w.r.t. the BAU case. This would be in line with ex-ante evidence (Bellora and Fontagné (2022), Korpar et al. (2023)). Under a hypothetical EU-India FTA, exports from India to the EU are expected to rise above BAU-level exports, due to lower import tariffs (Felbermayr et al. (2017), Gallina et al. (2020)). As to the interplay of CBAM and the FTA, it is assumed that while the FTA might boost India's exports to the EU, CBAM could have a dampening effect. The crucial question of interest is whether the CBAM's effect will be strong enough to reverse a potential positive change in trade flows.

CO2 emissions are assumed to change in proportion with trade effects, just with the opposite sign. Mirroring ex-ante evidence (Bellora and Fontagné (2022), Korpar et al. (2023)), CO2 emissions are expected to decrease in the CBAM standalone scenario. While CBAM is expected to induce lower CO2 emissions in India, an FTA between the EU and India is expected to lead to higher CO2 emissions. Similarly to trade flows, the combination of CBAM and the EU-India FTA might cause a level of CO2 emissions higher than under a standalone CBAM, but potentially lower than under a pure FTA.

3.3.2 Welfare

When two regions reduce trade barriers in a multilateral world, the overall impact on aggregate welfare is uncertain beforehand. A first reason for this uncertainty lies in the ambiguous interplay between the shift of trade towards the cheapest suppliers and the linked changes in tariff revenues. In their model with intermediate input-output linkages, Gallina et al. (2020) find an absolute decrease in India's tariff revenue. Under the "shallow" tariff elimination scenario, Felbermayr et al. (2017) find Indian tariff revenue to decrease by 0.36 pp. Second, there is the possibility that lower tariffs encourage a country to redirect imports away from a more efficient trading partner to a less efficient one. This redirection occurs because the less efficient partner's disadvantage is offset by the preferential elimination of the tariff (trade diversion). Furthermore, welfare effects might hinge on the model structure (Balistreri and Rutherford (2012)). Given the difficulties, this paper argues for negative welfare effects linked to an EU-India FTA, on average. CBAM is not assumed to influence welfare, neither for the EU, nor for India.

3.4 The New Quantitative General Equilibrium Trade Model

To obtain counterfactual changes in trade, CO2 emissions, and welfare, a general equilibrium model following Costinot and Rodríguez-Clare (2014) is adopted. Reflecting the ICIO table structure, the model features industries which are connected (inter-)nationally through input-output linkages. A deeper insight into the mathematical formulations underlying the model is given in Appendix A.

The rationale of changes in trade flows, CO2 emissions, and welfare causal to a tariff change is reflected in the mechanisms underlying the general equilibrium model. Demand for goods and services depends on both the Armington assumption of nationally differentiated products serving as the motivation to trade and tariffs as bilateral import barriers between countries. Tariffs imply that consumers pay more a higher price than under zero trade costs, a flat world scenario. Trade liberalisation is considered to remove these distortions, for example by triggering efficient specialisation patterns in goods production between countries. Once allocated to the most efficient producer, under perfectly competitive goods markets, consumers can buy more of a good at a given price. Since CBAM works with border adjustment tariffs, the mechanism underlying changes in trade flows is assumed to apply to an FTA and CBAM, likewise. In terms of welfare, the effects are ambiguous. While on the one hand, an increase in production translates into higher wages which allow consumers to source more goods and services from a given country, one the other hand, a reduction in tariff revenues dampens the impact of an increase in income on real expenditure. In the analysis, while welfare is assumed to increase with real income, it is orthogonal to carbon emissions.

4 Results

4.1 Trade and CO2 Emissions

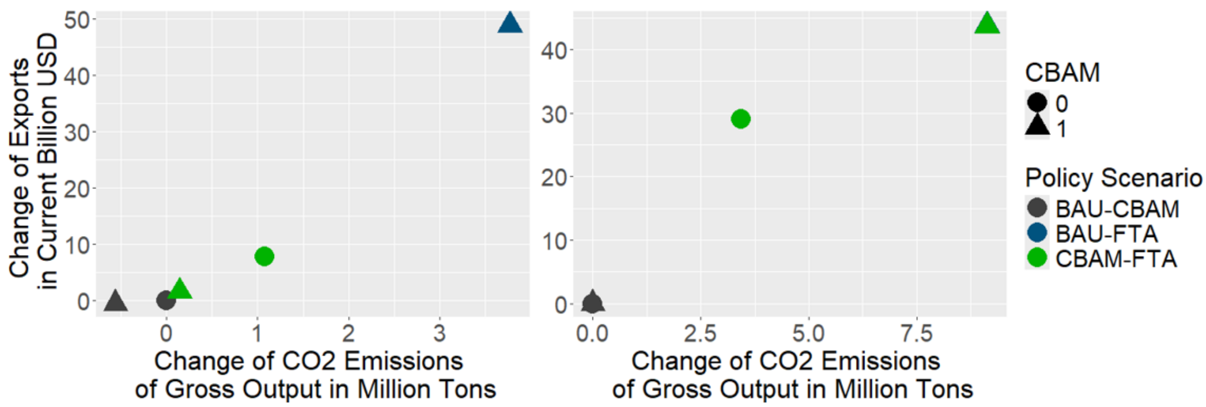

Fig. 5 **Left**: Counterfactual Changes in India's Exports to the EU and India's CO2 Emissions, for CBAM and non-CBAM Industries. **Right**: Counterfactual Changes in the EU's Exports to India and the EU's CO2 Emissions, for CBAM and non-CBAM Industries.

CBAM. Figure 5 shows the effects of three different policy scenarios on bilateral exports and production-based CO2 emissions, as retrieved in the counterfactual general equilibrium trade model. Under a Carbon Border Adjustment Mechanism (CBAM) extending to all product lines within an industry aggregate, exports from India to the EU and production-based CO2 emissions would decrease (see Figure 5, left). This effect would be disproportionately reversed by a hypothetical EU-India Free Trade Agreement (FTA) with a tariff reduction scheme as in Gallina et al. (2020) Scenario 1c. The decrease in CO2 emissions linked to the slight decline in exports from India to the EU would be more than offset by an EU-India FTA. Especially CBAM industries would be affected, with a projected increase in bilateral trade of up to 100 bn USD.

Compared to the baseline equilibrium, the current CBAM design (BAU-CBAM) reduces India's overall export value in the new equilibrium by 501 mn. USD, which makes up 0.1% of India's overall export value and 0.01% of India's GDP. This finding is similar to Korpar et al. (2023) who find India's export value and GDP to decrease by 0.3% and 0.03%, respectively. 226 mn. USD of India's export value loss would pertain to the iron and steel industry aggregate (14) alone, which seems plausible against the backdrop of Zhong and Pei (2022) who find a reduction of 647 mn. under Scope 1 and 2 and all nine EITE industries. Across all industry aggregates, the reductions in CBAM exports seem a bit higher than in Simola (2021), which can be explained given her assessment at the HS 6-digit level and the differences brought about by the industry aggregate conversion[2]. Given the mentioned constraints, the cost estimate of 501 mn. USD is in line with those by Cosbey et al. (2021), 190 mn. EUR and Simola (2021), 220 mn. EUR.

Measured in absolute terms, Russia, the USA, China and Japan each would lose more due to CBAM than India, with roughly 7 bn. USD combined. In relative terms, Russia would be most affected by CBAM, which would melt 0.5% of its export value and 0.07% of its GDP. The EU would increase home market trade by 9.5 bn. USD, equal to 0.03% of its GDP. Also New Zealand, Norway and Switzerland would gain from CBAM partly thanks to their own ETS schemes in place.

Regarding carbon emissions under CBAM, India would incur a decrease of 0.6 mn. tons of CO2 (-0.03%). Of this decrease, 0.5 mn. tons alone are mitigated via a decline in iron and steel production. The EU however, would experience a rise of 1.5 million tons of CO2 (+0.06%) due to the aforementioned increase in home market trade. Overall, carbon emission mitigation outweighs this latter increase due to trade deflection such that there is a net decline in CO2 emissions under CBAM. This is largely influenced by a decline of 5.5 mn. tons of CO2 emitted in Russia (-0.39%).

EU-India FTA. While, as shown in Figure 5, India's export value to the EU would rise by 12% (+56 bn. USD), overall, the EU-India FTA is found to dampen India's GDP by 2.6 bn. USD. This is due to a reduction of intra-Indian trade which outweighs India's surge in exports to the EU. This finding is most likely attributable to the features of the model ignoring intermediate input linkages. Both in absolute and relative terms, the 56 bn. USD (12%) increase in export value under a pure tariff liberalisation scenario falls short of the potential gains in trade of 84 bn. EUR (91%) found in the "deep" FTA scenario of Felbermayr et al. (2017) that includes the removal of NTMs. Under an FTA, the EU's export value to India would rise by 73 bn. USD. However, also for the EU, there is substantial trade diversion away from the home market, mirroring the finding of Felbermayr et al. (2017). Yet, the magnitudes differ (-46 bn. USD vs. -6 bn. USD). Again, this finding is most likely attributable to the lack of intermediate inputs.

Also Gallina et al. (2020) find larger relative average changes in exports due to an EU-India FTA. Across the scenarios, exports from the EU to India increase by 52 to 56%, while exports from

[2] In comparison, the results are 192 mn. EUR in steel, 23 mn. EUR in aluminium, and 1 mio. EUR in fertilizers and cement versus 226 mn. USD in iron and steel, -2 mn. USD in aluminium, -18 mn. USD in fertilizers and cement.

India to the EU increase by 31 to 33%. At the industry level, results are slightly different. In Gallina et al. (2020), exports from India increase most in the textiles, apparel, and leather sector, followed by chemicals and basic metals. In this study, chemicals witness the highest absolute increase with a plus of 48 bn. USD, followed by textiles (+18 bn. USD) and food, beverages and tobacco (+871 mn. USD). Almost doubling (3 to 6 bn. EUR), the basic metals export value increases most among all sectors from the EU, followed by electrical equipment and electronics in Gallina et al. (2020). In contrast, it is likewise chemicals that sees the highest increase (+41 bn. USD). However, the increase in basic metals found in Gallina et al. (2020) is reflected in the results.

In parallel to the overall decrease in trade value under the EU-India FTA, India would incur a decrease of 9.5 mn. tons of CO2 (-0.5%). Taking iron and steel as the example, India would export slightly more iron and steel to the EU, which would be mirrored by a CO2 increase of 0.3 mn. tons. On the other hand, India would lose 1.2 mn. tons of CO2 due to a decline of home market production. Since under the FTA, mostly chemicals exports surge, 3.4 mn. tons of CO2 would additionally be emitted. The EU however, would experience a rise of 10 million tons of CO2 (+0.29%), mainly driven by the surge in chemicals exports portrayed in Figure 5 (right).

CBAM & EU-India FTA. In the currently most likely scenario of CBAM in place ahead of the EU-India FTA, India's overall export value sees a 49 bn. USD loss vis-à-vis a CBAM equilibrium (-13 mn. tons of CO2). This is larger than under the BAU-FTA scenario. In percentage terms, nearly all industry aggregates except those tackled by CBAM see a similar increase from CBAM to the FTA as compared to BAU to the FTA. As shown in Table 1, the overall relative decline in additional exports under CBAM-FTA compared to BAU-FTA is remarkable: while under BAU-FTA, chemicals exports from India to the EU increase by 48 bn. USD, under CBAM-FTA their rise would be limited to 1.6 bn. USD. It seems that under a CBAM baseline equilibrium, the same reduction of FTA tariffs on chemicals has a weaker effect than if BAU baseline tariffs were in place. This suggests that although the CBAM tariffs might be small in magnitude, they have a potential to alter the global economic pattern. This pattern is consistent also with the other industry aggregates affected by CBAM. Under CBAM-FTA, iron and steel and fertilizers, and fabricated metals see a tenfold decline in export value vis-à-vis the BAU-FTA scenario. In contrast, export values of all other industry aggregates increase w.r.t. the BAU-FTA scenario. Transferred to the realm of environmental effects, this indicates that once a CBAM is in place, an EU-India FTA does not lead to substantial carbon emission leakage, at least in the CBAM industries. On the contrary, CO2 emission decrease further w.r.t. the BAU-FTA scenario. In their exports to the EU, iron and steel would emit a mere 0.03 mn. tons of CO2 more than under CBAM (compare to 0.3 mn. tons).

In stark contrast to India, the EU would further increase its export value up to 76 bn. USD. tons of CO2 embodied in production. Almost offsetting the decline of India's CO2 emissions, this would be linked to 12 mn. additional tons of CO2. There are signs of carbon leakage appearing elsewhere in the world, expressed by slightly positive emission changes in Costa Rica, Mexico, and Peru.

Industry	Absolute Changes					
	BAU-CBAM		BAU-FTA		CBAM-FTA	
	Trade	CO2	Trade	CO2	Trade	CO2
1	0.0	0.0	28.0	0.0	28.1	0.0
2	0.0	0.0	12.5	0.0	12.5	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	1.6	0.0	1.6	0.0
5	0.0	0.0	871.4	0.0	871.6	0.0
6	0.0	0.0	1851.0	0.1	1851.0	0.1
7	0.0	0.0	35.5	0.0	35.5	0.0
8	0.0	0.0	3.7	0.0	3.7	0.0
9	0.0	0.0	233.0	0.0	233.1	0.0
10	-255.4	0.0	48461.4	3.4	1564.4	0.1
11	0.0	0.0	40.6	0.0	40.6	0.0
12	0.0	0.0	433.4	0.6	433.4	0.6
13	-17.9	0.0	24.1	0.0	2.6	0.0
14	-225.7	-0.5	131.2	0.3	13.9	0.0
15	-2.3	0.0	267.8	0.0	32.5	0.0
16	0.0	0.0	173.4	0.0	173.4	0.0
17	0.0	0.0	423.8	0.0	423.8	0.0
18	0.0	0.0	489.0	0.0	489.1	0.0
19	0.0	0.0	93.5	0.0	93.5	0.0
20	0.0	0.0	3.1	0.0	3.1	0.0
21	0.0	0.0	24.0	0.0	24.0	0.0
22	0.0	0.0	3106.0	0.3	3107.0	0.3

Table 1 Counterfactual Changes in Exports and Production-Based CO2 Emissions of India's Industries under an EU CBAM (BAU-CBAM), an EU-India FTA (BAU-FTA), and an EU-India FTA under CBAM (CBAM-FTA), in Current Million USD for Exports and Million Tons for CO2 Emissions.

4.2 Welfare

CBAM. At the country level, CBAM is not found to change real income, except for Russia. This is in contrast to Korpar et al. (2023) who find a welfare decrease of 0.02% for India and an increase of 0.02% for the EU, on average. In an Armington model, Balistreri and Rutherford (2012) find welfare losses of 2% for non-coalition countries due to border carbon adjustment (BCA). Hence, the hypothesis of Lanzi et al. (2012) that BCAs cause competitiveness losses for non-acting countries is largely confirmed for Russia, which is substantially exposed to CBAM.

EU-India FTA. Under an EU-India FTA, India would experience a static welfare gain of 0.04%. Under CBAM tariffs already in place, India would lose welfare under an EU-India FTA. This percentage increase in GDP is somewhat lower than the tally obtained in Felbermayr et al. (2017). Depending on the depth of the EU-India FTA annual real income could rise by 0.7 to 1.3% ("shallow" vs. "deep"). For the EU, the proposed FTA is expected to increase per capita income between by about 0.01% per year, again a smaller change as compared to Felbermayr et al. (2017). Perhaps due to the similar base year and underlying data, the gains from trade resemble Gallina et al. (2020) more. They find welfare gains for India of 0.1 to 0.3% with respect to the baseline. Across all scenarios, an EU member state would gain between 0.02 and 0.03%, on average.

CBAM & EU-India FTA. In case an EU-India FTA is phased in once CBAM had materialized, welfare effects would be adverse for India. This might be related to the loss of exports to the EU in

Country	Policy Scenario		
	BAU-CBAM	BAU-FTA	CBAM-FTA
ARG	100	100	100
AUS	100	100	100
BRA	100	100	100
CAN	100	100	100
CHE	100	99.99	100
CHN	100	100	100
COL	100	100	100
CRI	100	100	100
EUN	100	100.01	100.02
IDN	100	100	99.98
IND	100	100.04	99.56
JPN	100	100	100
KAZ	100	100	100
KOR	100	100	100
MAR	100	99.98	99.98
MEX	100	100	100
NOR	100	100	99.99
NZL	100	100	100
PER	100	100	100
ROW	100	100	100.08
RUS	99.99	100	100.02
SAU	100	99.99	99.98
THA	100	100	100
TUR	100	100	100
TWN	100	100	100
USA	100	100	100
VNM	100	100	100
ZAF	100	100	100

Table 2 Welfare Effects of an EU CBAM (BAU-CBAM), an EU-India FTA (BAU-FTA), and an EU-India FTA under a CBAM (CBAM-FTA), in Percentage Changes from 100.

CBAM industries. Under a CBAM, the EU would be able to sustain its competitive position further. The table capturing gains from trade only, it remains to show the CO2 emission changes related: while India would save 0.7% of its CO2 emissions, the EU would increase hers by 0.5%. In absolute terms, India would save more CO2 than the EU would additionally emit (-13 vs. 12 mn. tons).

4.3 Discussion

4.3.1 Caveats

A strong caveat is the assumption that CBAM applies to industry aggregates, and not to the more granular HS 6-digit level. This is linked to data availability: while CO2 intensity data is available for each country at the ISIC 2-digit level (OECD (2022c)), only a few countries provide them at the HS 6-digit level. It is important to consider that CBAM has a limited scope: while CBAM tackles over 100 HS 6-digit tariff lines in iron and steel (14), its coverage is limited to 22 tariff lines in aluminium (15), and four tariff lines in cement (13). In the chemicals industry aggregate (10), CBAM applies to eleven fertilizer tariff lines, three tariff lines covering ammonia, and one pertaining to potassium nitrate (Cosbey et al. (2021)). The variance in the frequency ratios is mirrored in the coverage ratios. While 52% of India's basic metals (14) export value to the EU was under CBAM, it covered a mere 0.01% of India's chemicals (10) export value to the EU, in 2014. The wide sectoral coverage of CBAM as modelled might not be necessarily bad, since several extensions to the initial CBAM are discussed. The EU Parliament proposes to expand CBAM to include organic chemicals, hydrogen, and polymers (Hufbauer et al. (2022)).

The discussion on the level of disaggregation leads to a reminder of CBAM as a firm-related policy and hence, a warning. Interpreting results at the industry aggregate level might be problematic since reshuffling of clean and dirty products to either the EU or non-allied countries may happen at the firm-level[3]. Still, the analysis is able to capture sectoral dynamics between EITE industries and cleaner industries.

Moreover, this analysis abstracts from policy-relevant emission scopes. In the current proposal, CBAM tariffs vary depending on the amount of CO2 emitted in earlier stages of the value chain. The scope of emissions extends from direct emissions linked to the production of the good at the plant level to indirect emissions (electricity and other emissions linked to inputs). By taking into account only direct CO2 emission linked to the production of the good at the installation level, any deeper scope of emissions is neglected, here.

Further major flaws, the model abstracts from intermediate goods linkages. The lack of intermediate goods linkages is the most striking difference to the framework in Gallina et al. (2020) and renders a direct comparison more difficult. Costinot and Rodríguez-Clare (2014) find increasing welfare gains when using more complex models that include intermediate input structures. The reason is that models with intermediate input patterns produce more realistic results since the change in prices is magnified through tradeable intermediates used in production, which increase welfare via a rise in expenditure.

A further driver of welfare effects is related to the idea of positive optimal tariff levels (Gros (1987), Helpman and Krugman (1989)). Using a fictitious example of an import tariff for a group of countries, Costinot and Rodríguez-Clare (2014) demonstrate that welfare is highest when maintaining a tariff level of around 20% (see Costinot and Rodríguez-Clare (2014), Figure 4.1, p. 228). Moreover, optimal tariff size is found to differ depending on the model structure. In the BCA scenario of Balistreri and Rutherford (2012), the Armington structure indicates small coalition gains and large non-coalition losses compared to a Melitz (2003) -type monopolistic competition framework. The explanation for negative welfare effects might thus be traced to the assumption of national product differentiation and hence, the existence of large optimal tariffs. This implies significant room for the policy authority to exercise market power through a beggar-thy-neighbor tariff (Balistreri and Markusen (2009)). Balistreri and Rutherford (2012) show that this is not the case in monopolistic competition models.

More recently, a vivid debate on whether and how aggregate effects of trade on CO2 emissions differ from the effects at the firm level has emerged (Balistreri and Rutherford (2012), Copeland (2021)). In theory, as regulated-region (EU ETS) prices increase, non-regulated regions (India) experience a lowering of the export threshold, inducing a reallocation of resources between differently

[3]Russia's largest aluminum producer Rusal is planning reshuffling: only low-carbon aluminum from green hydro-powered facilities would be shipped to the EU (Dröge (2021))

productive plants. Relative to unregulated regions, productivity falls in regulated regions. If the EU places restrictions on the import of energy-intensive goods from India, production costs in India rise and thus raise the threshold for export engagement. Again, this reallocates resources between more versus less productive plants within the industry. A popular hypothesis is that competitive effects of subglobal policy might thus be magnified under a heterogeneous firms structure (Balistreri and Rutherford (2012)). Comparing the Armington-style model to a Melitz (2003) -type model with monopolistic competition, Balistreri and Rutherford (2012) find larger carbon leakage rates and larger competitiveness effects related to climate policy in the latter model. The Armington model is found to limit trade responses relative to the initial calibration point, thus failing to account for the productivity changes predicted by the Melitz structure. Relative to an Armington structure, the intra-industry reallocation of non-coalition resources into more productive firms increases overall productivity, which translates into overall non-coalition welfare improvements.

Regarding the assumption of homogeneous firms and national product differentiation, other models such as a Melitz (2003) -type monopolistic competition framework might better capture non perfectly competitive market structures and firm heterogeneity. Up to this day, the extent to which technique effects are driven by real income gains from trade have remained unclear (Copeland (2021)). Yet, firm-level heterogeneity models have found evidence for technique effects in India. Studying the impact of trade on GHG emissions by Indian manufacturing firms Martin (2011) finds that within a given industry and year, plants with higher total factor productivity have lower fuel expenditure per USD of output.

Using emission intensity data at the firm-product level, Barrows and Ollivier (2018) find that emission intensity in India dropped significantly between 1990 and 2010 through reallocations across firms. Drawing upon a monopolistic competition framework, Barrows and Ollivier (2018) find that the effects of technological upgrading on CO2 emission intensity differ at the industry- and firm levels. While on the one hand, pro-competitive market developments lead to an improvement in the aggregate emission intensity across firms, on the other hand, product mix might increase emission intensity within firms.

4.3.2 Pro-trade vs. pro-environmental policy?

While free trade agreements are a very commonly used and accepted tool, a similar mechanism as the EU CBAM has not been introduced before (Bergin et al. (2021)). Hence, the reactions of the EU trading partners' reactions to CBAM are critical for its success. For several years, policymakers have been worrying about the implications of using carbon tariffs because of ongoing international climate policy negotiations (Houser et al. (2008))) or trade relations: Böhringer et al. (2022) perceive the risk of trade conflicts as one explanation of the reluctance to implement border carbon adjustments to date. Bellora and Fontagné (2022) describe the CBAM as a target conflict between ambitious commitments to reduce global GHG emissions and the maintenance of the open multilateral trading system. The latter could be endangered as trading partners might impose protectionist countermeasures to carbon border tariffs (Höslinger et al. (2022)).

Reactions to CBAM by the EU's trading partners range from being supportive to skeptical to opposed. In line with the climate club proposal (Nordhaus (2015), and recently Bierbrauer et al. (2021)), Canada, the United Kingdom, and the United States are considering own carbon border adjustments, while Japan and South Korea are interested in working with the EU on CBAM. China has meanwhile started its own emission trading system and might try to credit its own efforts when calculating CO2 emissions in exports. Large emerging economies, notably the BASIC group comprising Brazil, China, and India are calling on the EU to dispense with the instrument entirely (Dröge (2021)). Indian policymakers wish for a "grand bargain" for climate goals, like trade deals, in which both sides make concessions. Having collected responses from further developing countries, Bergin et al. (2021) conclude that all the WTO conform options proposed by the EU warrant a renegotiation of tariff arrangements in existing bilateral trade agreements. Also Payosova et al. (2022) suggest that India should take the ongoing EU-India FTA negotiations as an opportunity to discuss CBAM issues.

This study cannot reject the hypothesis that under a CBAM, average CO2 emissions in the EU will increase due to a loss of imports from the rest of the world. Indeed, the EU is able to achieve a desired environmental steering effect via CBAM. Likewise, the study finds that in case of an EU-India FTA, CO2 emissions will increase on both sides. Interestingly, India's CO2 emissions will decline along with an overall decline of India's home market. A substantial share of India's foregone within-country exports are replaced by products originating from the EU. The interplay of the EU CBAM with the EU-India FTA reveals that even in case of a tariff liberalisation of 90% after some years towards the future, CBAM might distort EU-India trade adversely.[4] As a consequence, less EITE products would be exported under the FTA. Again, this is evidence for an intended environmental steering effect. In a nutshell, this study suggests that CBAM tariffs have a potential to alter the global economic pattern and shape an industry's overall competitiveness. In this regard, this study confirms the claim that especially CBAM might adversely affect India's steel industry with longstanding export linkages to the EU (see Payosova et al. (2022)). All the while, the interplay of the CBAM with the EU-India FTA would signal a divergence as to the burden of emission mitigation. On average, the EU-India FTA cannot achieve to reduce the gap in production-based CO2 emissions. While, no surprise, under BAU-CBAM, the EU emits 1.5 mn. tons (0.06%) more, India saves 0.6 mn. tons (-0.03%). But, when considering CBAM-FTA, the sign of the gap remains. In the most likely scenario, India would mitigate 13 mn. tons of CO2 (-0.7%) while the EU would emit 12 mn. tons (+0.5%) more. Given these dynamics pertaining to the interplay of the EU-India FTA with CBAM, the opposition to "pro-environmental" policies might even further increase.

[4] It is important to note that CBAM is assumed to apply to each product line within a broader industry aggregate. For more details, see Appendix B.

5 Conclusion

This paper intends to contribute towards the debate on the right policy mix to achieve both economic competitiveness, and environmental protection, under the assumption that competitiveness-related and climate change mitigation policies are in tension. The currently negotiated EU-India FTA and the CBAM are taken as a case-in-point to deliver ex-ante predictions on the interplay of both policy areas. To this aim, this paper assesses the prospects of the planned CBAM and the negotiated EU-India FTA to alter trade, CO2 emissions and welfare of India and the EU in a counterfactual general equilibrium trade model, frequently applied in international trade research.

This study suggests that CBAM tariffs have a potential to alter the global economic pattern and shape an industry's overall competitiveness. In this regard, this study confirms the claim that especially CBAM might adversely affect India's steel industry with longstanding export linkages to the EU. However, India is to face this substantial reduction of exports to the EU only in case of a CBAM applying to significantly more tariff lines than as of today. Currently covering less than 1% of India's exports to the EU, notably, India's chemicals sector would be adversely affected by an extension of CBAM tariff lines.

While boosting the overall trade volume between the EU and India, an EU-India FTA would only partly reverse the trade volume reductions which India faces as a consequence of CBAM. Especially those industry aggregates currently under CBAM might experience less than otherwise exports to the EU in case of an FTA. A second major finding is that CO2 emission changes as a global negative externality to the one-sided welfare-enhancing gains from trade are unequally distributed between the parties. While the EU emits more CO2 than the rest of the world under all policy scenarios, India witnesses a net decline in CO2 emissions even under the FTA scenario.

Towards the near future, classical tariff policy remains a tool of choice of trade policy makers. Yet, a joint investigation of "pro-trade" and "pro-environmental" policies is more and more sought after, especially since unilateral policies result in global externalities. Moreover, via trade policy, the outcomes of border adjustment schemes can be steered, and vice versa. Ultimately, more research on the trade-environmental policy frontier may help decision-makers engaged in negotiating free trade agreements in making better-informed decisions towards a tariff policy in line with desired environmental outcomes, and vice versa.

Appendix

A The Counterfactual General Equilibrium Trade Model

A.1 The Armington Model

Consider a world economy comprising $i = 1, \ldots, n$ countries, each endowed with Q_i units of a distinct good $i = 1, \ldots, n$.

Preferences. Each country is populated by a representative agent whose preferences are represented by a Constant Elasticity of Substitution (CES) utility function:

$$C_j = \left(\sum_{i=1}^{n} \psi_{ij}^{(1-\sigma)/\sigma} C_{ij}^{(\sigma-1)/\sigma} \right)^{\sigma/(\sigma-1)} \tag{1}$$

where C_{ij} is the demand for good i in country $j; \psi_{ij} > 0$ is an exogenous preference parameter; and $\sigma > 1$ is the elasticity of substitution between goods from different countries. The associated consumer price index is given by

$$P_j = \left(\sum_{i=1}^{n} \psi_{ij}^{1-\sigma} P_{ij}^{1-\sigma} \right)^{1/(1-\sigma)} \tag{2}$$

where P_{ij} is the price of good i in country j.

Trade Costs. International trade between countries is subject to iceberg trade costs. In order to sell one unit of a good in country j, firms from country i must ship $\tau_{ij} \geq 1$ units, with $\tau_{ii} = 1$. For there to be no arbitrage opportunities, the price of good i in country j must be equal to $P_{ij} = \tau_{ij} P_{ii}$. The domestic price P_{ii} of good i, in turn, can be expressed as a function of country i 's total income, Y_i, and its endowment: $P_{ii} = Y_i / Q_i$. Combining the two previous expressions one gets

$$P_{ij} = Y_i \tau_{ij} / Q_i. \tag{3}$$

Trade Flows. Let X_{ij} denote the total value of country j 's imports from country i. Given CES utility, maximizing utility subject to the budget constraint $E_i = P_i C_i = X_i$ for each country, we obtain optimal demand, and thus bilateral trade flows

$$X_{ij} = \left(\frac{\psi_{ij} P_{ij}}{P_j} \right)^{1-\sigma} E_j \tag{4}$$

where $E_j \equiv \sum_{i=1}^{n} X_{ij}$ is country j 's total expenditure. Combining Equation 2 - Equation 4 , we obtain

$$X_{ij} = \frac{(Y_i \tau_{ij})^{1-\sigma} \chi_{ij}}{\sum_{l=1}^{n} (Y_l \tau_{lj})^{1-\sigma} \chi_{lj}} E_j,$$

where $\chi_{ij} \equiv (Q_i / \psi_{ij})^{\sigma-1}$. In order to prepare the general analysis of Section 3, one can let $\varepsilon \equiv \partial \ln (X_{ij}/X_{ij}) / \partial \ln \tau_{ij}$ denote the elasticity of imports relative to domestic demand, X_{ij}/X_{ij}, with respect to bilateral trade costs, τ_{ij}, holding income levels fixed. ε is referred to as the **trade elasticity**. In this Armington model, it is simply equal to $\sigma - 1$. Using the previous notation, one can rearrange the expression above as

$$X_{ij} = \frac{(Y_i \tau_{ij})^{-\varepsilon} \chi_{ij}}{\sum_{l=1}^{n} (Y_l \tau_{lj})^{-\varepsilon} \chi_{lj}} E_j. \tag{5}$$

Equation 5 is the so-called **gravity equation**.

Competitive Equilibrium. In the competitive equilibrium, budget constraint and goods market clearing imply $Y_i = E_i$ and $Y_i = \sum_{j=1}^{n} X_{ij}$, respectively, for all countries i. Together with Equation 5, these two conditions imply

$$Y_i = \sum_{j=1}^{n} \frac{(Y_i \tau_{ij})^{-\varepsilon} \chi_{ij}}{\sum_{l=1}^{n} (Y_l \tau_{lj})^{-\varepsilon} \chi_{lj}} Y_j. \tag{6}$$

This results in a system of n equations with n unknowns, $\mathbf{Y} \equiv \{Y_i\}$. According to Walras's Law, one of these equations is redundant, implying that income levels are only determinable up to a constant. Once income levels are known, expenditure levels, $\mathbf{E} \equiv \{E_i\}$, can be computed using the budget constraint, while bilateral trade flows, $\mathbf{X} \equiv \{X_{ij}\}$, can be derived using the gravity equation. This concludes the description of the Armington model.

Quantifying the Welfare Implications Using the Gravity Equation

Now, it is illustrated how the gravity equation can be used to quantify the welfare consequences of globalization. For simplicity, a shock to trade costs from $\tau \equiv \{\tau_{ij}\}$ to $\boldsymbol{\tau'} \equiv \{\tau'_{ij}\}$ is assumed. The same analysis generalizes in a straightforward manner to preference and endowment shocks. To quantify the welfare consequences of a trade shock in a given country j, two steps are taken. First, changes in real consumption, $C_j \equiv E_j/P_j$, are inferred from changes in macro variables, X and Y. Second, changes in macro variables are computed.

Welfare. In this model, welfare changes in country j, correspond to percentage changes in real consumption. Such changes correspond to the equivalent variation associated with a foreign shock (expressed as a share of expenditure before the shock). Namely, percentage changes in real consumption measures the percentage change in income that the representative agent would be willing to accept in lieu of the shock to happen.

The initial finding indicates that changes in real consumption can be deduced using only two key measures: (i) observed changes in the proportion of spending on domestic products, denoted as $\lambda_{ij} \equiv X_{ij}/E_j$; and (ii) the trade elasticity present in the gravity equation, represented by ε.

Let us begin by assuming an infinitesimal alteration in trade costs from τ to $\tau + d\tau$. The price index equation reveals

$$
\begin{aligned}
dlnP_j &= \frac{1}{1-\sigma} dln \left(\sum_{i=1}^{n} \psi_{ij}^{1-\sigma} P_{ij}^{1-\sigma} \right) \\
&= \frac{1}{1-\sigma} \frac{\sum_{i=1}^{n} \psi_{ij}^{1-\sigma} P_{ij}^{1-\sigma} (1-\sigma) dlnP_{ij}}{\sum_{i=1}^{n} \psi_{ij}^{1-\sigma} P_{ij}^{1-\sigma}} \\
&= \sum_{i=1}^{n} \frac{\psi_{ij}^{1-\sigma} P_{ij}^{1-\sigma}}{\sum_{i=1}^{n} \psi_{ij}^{1-\sigma} P_{ij}^{1-\sigma}} dlnP_{ij} \\
&= \sum_{i=1}^{n} \lambda_{ij} d \ln P_{ij}
\end{aligned}
$$

Here, the last equation utilized a combination of Equation 2 and Equation 4, while $\lambda_{ij} \equiv X_{ij}/E_j$ represents the portion of expenditure on goods from country i in country j.

This equation can be further simplified. From the relationship between foreign and domestic trade shares, we can derive the following expression for the derivative of the bilateral price index:

$$
\begin{aligned}
dln\lambda_{ij} - dln\lambda_{jj} &= dln \left(\psi_{ij}^{1-\sigma} P_{ij}^{1-\sigma} P_j^{1-\sigma} \right) - dln \left(\psi_{jj}^{1-\sigma} P_{jj}^{1-\sigma} P_j^{1-\sigma} \right) \\
&= (1-\sigma) \left(dlnP_{ij} - dlnP_{jj} \right) \\
&\Leftrightarrow \\
\frac{dln\lambda_{ij} - dln\lambda_{jj}}{1-\sigma} + dlnP_{jj} &= dlnP_{ij}
\end{aligned}
$$

As a result, when substituted into the expression for the derivative of the national price index, the following expression solely in terms of the domestic trade share and domestic price index is obtained:

$$
\begin{aligned}
dlnP_j &= \sum_{i=1}^{n} \lambda_{ij} \left(\frac{dln\lambda_{ij} - dln\lambda_{jj}}{1-\sigma} + dlnP_{jj} \right) \\
&= \frac{\sum_{i=1}^{n} d\lambda_{ij} - dln\lambda_{jj}}{1-\sigma} + dlnP_{jj} \\
&= \frac{-dln\lambda_{jj}}{1-\sigma} + dlnP_{jj}
\end{aligned}
$$

where the conditions $\sum_{i=1}^{n} \lambda_{ij} = 1$ and $\sum_{i=1}^{n} \lambda_{ij} dln\lambda_{ij} = \sum_{i=1}^{n} d\lambda_{ij} = 1$ are satisfied.

Consequently, changes in real consumption, $C_j \equiv E_j/P_j$, in country j can be expressed as

$$
d \ln C_j = \left(d \ln E_j - d \ln P_{ij} \right) + \left(d \ln \lambda_{jj} / (1-\sigma) \right). \tag{7}
$$

Since there are no domestic trade costs, $\tau_{ij} = \tau'_{ij} = 1$, and trade is balanced, $Y_j = E_j$, equation (3) implies that the first term equals zero. In the simple Armington model, changes in real consumption depend solely on the variation in the relative price of imported versus domestic goods, P_j^M / P_{jj}, which is contingent on the share of expenditure on domestic goods, λ_{ij}, and the elasticity of substitution, σ. By employing Equation 7 and the definition of the trade elasticity $\varepsilon \equiv \sigma - 1$, one can derive

$$
d \ln C_j = -d \ln \lambda_{jj} / \varepsilon. \tag{8}
$$

Since this expression holds for any infinitesimal shock, the welfare consequences of significant changes from $\boldsymbol{\tau}$ to $\boldsymbol{\tau}'$ can be inferred by integrating the preceding formula:

$$\hat{C}_j = \hat{\lambda}_{ij}^{-1/\varepsilon}, \tag{9}$$

where $\hat{v} \equiv v'/v$ indicates the proportional change in any variable v between the initial and counterfactual equilibria. This analysis demonstrates that for any alteration in trade costs, two statistics - the trade elasticity, ε, and the changes in the share of expenditure on domestic goods, λ_{jj}-are adequate for inferring welfare changes.

Macroeconomic Indicators. At this juncture, it is established that, contingent on the trade elasticity, ε, fluctuations in real consumption are uniquely determined by alterations in λ_{jj}. The subsequent discussion outlines how gravity models can be utilized to anticipate the impact of trade shocks on trade flows in general and the share of expenditure on domestic goods, λ_{jj}, in particular. This approach has recently gained popularity, as highlighted by Dekle et al. (2008). One can regard this methodology as an "exact" rendition of Jones's hat algebra.

Let $\lambda_{ij} \equiv X_{ij}/\sum_l X_{lj}$ denote the portion of expenditure on goods from country i in country j. Given that the gravity equation holds in both the initial and the counterfactual equilibria, the expression is as follows:

$$\begin{aligned} dln\lambda_{ij} &= dln\left(\psi_{ij}^{1-\sigma} P_{ij}^{1-\sigma} P_j^{1-\sigma}\right) \\ &= (1-\sigma)\left(dlnP_{ij} - dlnP_j\right) \\ &= (1-\sigma)\left(dlnP_{ij} - \sum_{i=1}^{n} \lambda_{ij} d\ln P_{ij}\right) \\ &\Leftrightarrow \\ \hat{\lambda}_{ij} &= \frac{\left(\hat{Y}_i \hat{\tau}_{ij}\right)^{-\varepsilon}}{\sum_{l=1}^{n} \lambda_{lj} \left(\hat{Y}_l \hat{\tau}_{lj}\right)^{-\varepsilon}}. \end{aligned} \tag{10}$$

Alternate Calculation:

$$
\begin{aligned}
\lambda'_{ij} &= \frac{\left(Y'_i \tau'_{ij}\right)^{1-\sigma} \chi'_{ij}}{\sum_{l=1}^{n} \left(Y'_l \tau'_{lj}\right)^{1-\sigma} \chi'_{lj}} \\
&= \frac{\left(Y_i \tau_{ij}\right)^{1-\sigma} \chi_{ij} \left(\hat{Y}_i \hat{\tau}_{ij}\right)^{1-\sigma}}{\sum_{l=1}^{n} \left(Y_l \tau_{lj}\right)^{1-\sigma} \chi_{lj} \left(\hat{Y}_l \hat{\tau}_{lj}\right)^{1-\sigma}} \\
&= \frac{\lambda_{ij} \left(\hat{Y}_i \hat{\tau}_{ij}\right)^{1-\sigma}}{\sum_{l=1}^{n} \lambda_{lj} \left(\hat{Y}_l \hat{\tau}_{lj}\right)^{1-\sigma}} \\
&\Leftrightarrow \\
\hat{\lambda}_{ij} &= \frac{\lambda'_{ij}}{\lambda_{ij}} = \frac{\left(\hat{Y}_i \hat{\tau}_{ij}\right)^{-\varepsilon}}{\sum_{l=1}^{n} \lambda_{lj} \left(\hat{Y}_l \hat{\tau}_{lj}\right)^{-\varepsilon}}.
\end{aligned}
$$

In the counterfactual equilibrium, Equation 6 further implies

$$
\begin{aligned}
Y'_j &= \sum_{i=1}^{n} \lambda'_{ji} Y'_i \\
&\Leftrightarrow \\
\hat{Y}_j Y_j &= \sum_{i=1}^{n} \hat{\lambda}_{ji} \lambda_{ji} \hat{Y}_i Y_i
\end{aligned}
$$

Combining the two previous expressions yields

$$
\hat{Y}_j Y_j = \sum_{i=1}^{n} \frac{\lambda_{ji} \left(\hat{Y}_j \hat{\tau}_{ji}\right)^{-\varepsilon} \hat{Y}_i Y_i}{\sum_{l=1}^{n} \lambda_{li} \left(\hat{Y}_l \hat{\tau}_{li}\right)^{-\varepsilon}}. \tag{11}
$$

Despite the effects of trade costs, endowments, and preference shifters on bilateral trade flows, as indicated by τ_{ij} and χ_{ij} in Equation 5, Equation 11 shows that counterfactual changes in income, $\hat{\mathbf{Y}} \equiv \left\{\hat{Y}_i\right\}$, can be computed as the solution of a system of non-linear equations without the need to estimate any of these parameters. The initial expenditure shares, λ_{ij}, the initial income levels, Y_i, and the trade elasticity, ε, are all that is required to determine changes in income levels (up to normalization). With changes in income levels, one can then compute changes in the shares of expenditure on goods from different countries, $\hat{\lambda}_{ij}$, and changes in real consumption, $\hat{C}_j$, using equations Equation 10 and Equation 9, respectively.

Assuming a single factor of production, labor, in the Armington model, income equals labor income $Y_i = w_i L_i$. With fixed endowments, one has $Y'_i = w'_i L_i = \hat{Y}_i Y_i = \hat{w}_i \frac{L_i}{L_i} w_i L_i = \hat{w}_i Y_i$, and Equation 11 can be rewritten as

$$
\hat{w}_j Y_j = \sum_{i=1}^{n} \frac{\lambda_{ji} \left(\hat{w}_j \hat{\tau}_{ji}\right)^{-\varepsilon} \hat{w}_i Y_i}{\sum_{l=1}^{n} \lambda_{li} \left(\hat{w}_l \hat{\tau}_{li}\right)^{-\varepsilon}}. \tag{12}
$$

The Armington Model with Tariffs

Trade Costs. Let's consider a world economy akin to the aforementioned model. In this scenario, trade flows can be subject to import tariffs, leading to the generalization of Equation 3 as follows:

$$P_{ij} = Y_i \tau_{ij} \left(1 + t_{ij}\right) / Q_i, \tag{13}$$

where Y_i denotes factor income in country i, representing GDP net of tariff revenues, and $t_{ij} \geq 0$ signifies the ad-valorem tariff imposed by country j on goods from country i. Throughout the remainder of this section, $\phi_{ij} \equiv \tau_{ij} \left(1 + t_{ij}\right)$ denotes the total trade costs between country i and j.

Trade Flows. Given CES utility, the value of bilateral trade flows (inclusive of tariffs) is expressed by the following gravity equation:

$$X_{ij} = \frac{\left(Y_i \phi_{ij}\right)^{-\varepsilon} \chi_{ij}}{\sum_{l=1}^{n} \left(Y_l \phi_{lj}\right)^{-\varepsilon} \chi_{lj}} E_j \tag{14}$$

Competitive Equilibrium. When import tariffs are present, budget balance now demands $E_j = Y_j + T_j$, where $T_j \equiv \sum_{i=1}^{n} \frac{t_{ij}}{1+t_{ij}} X_{ij}$ represents the total tariff revenues in country j. The goods market clearing condition necessitates $Y_i = \sum_{j=1}^{n} \frac{1}{1+t_{ij}} X_{ij}$. Together with Equation 14, these two conditions imply:

$$\begin{aligned} T_j &\equiv \sum_{i=1}^{n} \frac{t_{ij}}{1+t_{ij}} \frac{\left(Y_i \phi_{ij}\right)^{-\varepsilon} \chi_{ij}}{\sum_{l=1}^{n} \left(Y_l \phi_{lj}\right)^{-\varepsilon} \chi_{lj}} \left(Y_j + T_j\right) \\ &= \frac{\sum_{i=1}^{n} \frac{t_{ij}}{1+t_{ij}} \frac{\left(Y_i \phi_{ij}\right)^{-\varepsilon} \chi_{ij}}{\sum_{l=1}^{n} \left(Y_l \phi_{lj}\right)^{-\varepsilon} \chi_{lj}} Y_j}{1 - \left(\sum_{i=1}^{n} \frac{t_{ij}}{1+t_{ij}} \frac{\left(Y_i \phi_{ij}\right)^{-\varepsilon} \chi_{ij}}{\sum_{l=1}^{n} \left(Y_l \phi_{lj}\right)^{-\varepsilon} \chi_{lj}}\right)} \\ &= \frac{\pi_j}{1 - \pi_j} Y_j \end{aligned}$$

Here, $\pi_j \equiv \sum_{i=1}^{n} \frac{t_{jj}}{1+t_{ij}} \frac{\left(Y_i \phi_i\right)^{-\theta} \chi_{ij}}{\sum_{l-1}^{n} \left(Y_i \phi_j\right)^{-t} x_j} \in (0,1)$ indicates the share of tariff revenues in country j's total expenditure. Consequently, $E_j = Y_j + T_j = Y_j + \frac{\pi_j}{1-\pi_j} Y_j = \frac{1}{1-\pi_j} Y_j$, leading to the following generalization of Equation 6:

$$Y_i = \sum_{j=1}^{n} \frac{1}{1+t_{ij}} \frac{\left(Y_i \phi_{ij}\right)^{-\varepsilon} \chi_{ij}}{\sum_{l=1}^{n} \left(Y_l \phi_{lj}\right)^{-\varepsilon} \chi_{lj}} \frac{Y_j}{1-\pi_j}, \tag{15}$$

This concludes the description of a competitive equilibrium with import tariffs.

Welfare. Finally, to determine the welfare change resulting from the alteration in import tariffs, we can begin with Equation 7. By integrating and taking into account that $E_j = Y_j / \left(1 - \pi_j\right)$, we get:

$$\hat{C}_j = \left(\frac{1-\pi_j}{1-\pi_j'}\right) \hat{\lambda}_{jj}^{-1/\varepsilon}, \tag{16}$$

where the share of tariff revenues in the initial and counterfactual equilibria is denoted by $\pi_j = \sum_{i=1}^{n} \frac{t_{ij}}{1+t_{ij}} \lambda_{ij}$ and $\pi_j' = \sum_{i=1}^{n} \frac{t_{ij}'}{1+t_{ij}'} \lambda_{ij} \hat{\lambda}_{ij}$, respectively. Similar to the preceding section, we can compute welfare changes using only a few sufficient statistics. It's not necessary to estimate all structural parameters of the model to evaluate the welfare effect of an arbitrary tariff change.

Macroeconomic variables. Once changes in factor income are determined, we can calculate changes in expenditure shares using Equation 14:

$$\hat{\lambda}_{ij} = \frac{\left(\hat{Y}_i \hat{\phi}_{ij}\right)^{-\varepsilon}}{\sum_{l=1}^{n} \lambda_{lj} \left(\hat{Y}_l \hat{\phi}_{lj}\right)^{-\varepsilon}} \tag{17}$$

Now, let's consider an arbitrary change in import tariffs from $\mathbf{t} \equiv \{t_{ij}\}$ to $\mathbf{t}' \equiv \left\{t'_{ij}\right\}$. To compute proportional changes in factor income, $\hat{\mathbf{Y}} \equiv \left\{\hat{Y}_i\right\}$, we can once again use the exact hat algebra. In the counterfactual equilibrium, Equation 15 further implies:

$$\begin{aligned} Y'_j &= \sum_{i=1}^{n} \frac{1}{1+t'_{ij}} \lambda'_{ji} \frac{Y'_i}{1-\pi'_j} \\ &\Leftrightarrow \\ \hat{Y}_j Y_j &= \sum_{i=1}^{n} \frac{1}{1+t'_{ij}} \hat{\lambda}_{ji} \lambda_{ji} \frac{\hat{Y}_i Y_i}{1-\pi'_j} \end{aligned} \tag{18}$$

where the share of tariff revenues in the counterfactual equilibrium is itself denoted by:

$$\pi'_i = \sum_{j=1}^{n} \frac{t'_{ji}}{1+t'_{ji}} \frac{\lambda_{ji} \left(\hat{Y}_j \hat{\phi}_{ji}\right)^{-\varepsilon}}{\sum_{l=1}^{n} \lambda_{li} \left(\hat{Y}_l \hat{\phi}_{li}\right)^{-\varepsilon}}.$$

By combining the two preceding expressions, we can derive the following:

$$\hat{Y}_j Y_j = \sum_{i=1}^{n} \frac{1}{1+t'_{ij}} \frac{\lambda_{ji} \left(\hat{Y}_j \hat{\phi}_{ji}\right)^{-\varepsilon}}{\sum_{l=1}^{n} \lambda_{li} \left(\hat{Y}_l \hat{\phi}_{li}\right)^{-\varepsilon}} \frac{\hat{Y}_i Y_i}{1-\pi'_i}, \tag{19}$$

From the combination of the previous expressions, one can solve for $\hat{\mathbf{Y}} \equiv \left\{\hat{Y}_i\right\}$ (up to a normalization). Although the previous system of equations is not as concise as Equation 11, it still does not directly depend on preference shifters, endowments, or trade costs. All that is necessary to determine changes in factor income levels, $\hat{Y}_i$, are the initial expenditure shares, λ_{ij}, the initial factor income levels, Y_i, and the trade elasticity, ε.

B Data

B.1 The Bilateral Industry-Level Tariff Scheme

BAU. The baseline tariffs draw upon simple average MFN and preferential tariff in % between all country-sector pairs from the UN TRAINS database (UN (2023)) and reflect the year 2014. The underlying nomenclatures range from H2 to H4. Wherever preferential bilateral country-sector tariffs are missing (e.g., ROW and CHE), MFN bilateral tariffs from UN (2023) are employed. Within-country tariffs as well as EU single market tariffs are set to 0.

BAU-CBAM. Country-sector level carbon tariffs $\tau_{l,c}^{i,j}$ follow Larch and Wanner, 2017

$$\tau_{l,c}^{i,j} = \begin{cases} 1 + \frac{E_l^j}{Y_l^j}(\lambda^j - \lambda^i), & \text{if } \lambda^j > \lambda^i \\ 1, & \text{if } \lambda^j \leq \lambda^i \end{cases}$$

where CBAM tariffs are assumed to be a product of the exporter's CO2 intensity $\frac{E_l^j}{Y_l^j}$ the carbon price differential $\lambda^j - \lambda^i$ between exporter country and importer country (Larch and Wanner (2017) and Korpar et al. (2023)). Unlike in Larch and Wanner (2017), the carbon price differential is assumed to be based on an ETS price instead of an "implicit carbon tax" (i's energy tax expenses over carbon emissions).

Starting from the BAU bilateral country-sector tariffs, CBAM tariffs are then calculated as follows. First, effective carbon rates at the country level are obtained from the OECD statistics on net effective carbon rates (OECD (2022a)) and are assembled following Garsous, Grégoire and Mateo, Mark and Teusch, Jonas and Theodoropoulos, Konstantinos and Tricaud, Astrid and Van Dender, Kurt (2023). Second, the existence of an ETS is checked for each country-industry pair and the carbon price differential is calculated. While the BAU tariff is assumed to hold for any country-pair not affected by CBAM, the product of the exporter's CO2 intensity and the carbon price differential applies to country-pairs subject to CBAM.

BAU-FTA. Tariffs for an EU-India FTA are calculated by subtracting a tariff reduction scheme for each targeted country-industry pair. In line with Gallina et al. (2020), Scenario 1c, it is assumed that both EU and India lower tariffs in all goods sectors by 90%, but:

- crops and animals (1): EU -10%, India -20%
- fishing and aquaculture (2): EU -90%, India -70%
- food, beverage and tobacco (5): EU -40%, India -30%
- motor vehicles (19) and other transport equipment (20): both EU and India -50%

This scenario assumes that the tariff reductions are proportional to the existing level of import tariff barriers. Henceforth, tariff reductions would be more difficult to achieve in relatively more protected industries (also see Figure 2).

Industry	BAU	BAU-CBAM	BAU-FTA	CBAM-FTA
1	0.034	0.034	0.0303	0.0302
2	0.090	0.090	0.0090	0.0090
3	0	0	0	0
4	0.000	0.000	0.0000	0.0000
5	0.100	0.100	0.0600	0.0600
6	0.078	0.078	0.0078	0.0078
7	0.028	0.028	0.0028	0.0028
8	0.001	0.001	0.0001	0.0001
9	0.003	0.003	0.0003	0.0003
10	0.054	0.055	0.0054	0.0498
11	0.006	0.006	0.0006	0.0006
12	0.047	0.047	0.0047	0.0047
13	0.025	0.043	0.0025	0.0408
14	0.014	0.038	0.0014	0.0366
15	0.020	0.020	0.0020	0.0184
16	0.024	0.024	0.0024	0.0024
17	0.026	0.026	0.0026	0.0026
18	0.017	0.017	0.0017	0.0017
19	0.057	0.057	0.0284	0.0283
20	0.013	0.013	0.0070	0.0066
21	0.024	0.024	0.0024	0.0024
22	0.016	0.016	0.0016	0.0016

Table 3 The Bilateral Tariff Scheme between the EU and India. Effectively Applied Simple Average Tariffs across Products within the Industry Aggregate. Source: UN (2023) for MFN and Preferential Simple Average Tariffs (%).

CBAM-FTA. Tariffs of the EU-India FTA under CBAM are then calculated by setting FTA tariffs on top of CBAM tariffs as a baseline. Currently, this scenario resembles the status quo of an EU-India FTA phased in after a CBAM which has been in place for one or more years, already.

B.2 The Industry Conversion Scheme

This study works with the simplifying assumption that - no matter whether the tariff code pertains to the list of CBAM goods or not - all products within an industry aggregate are fully affected by a CBAM tariff. However, as outlined in Annex I of the EU Commission's CBAM proposal, not every gross industry aggregate is affected by CBAM, equally. To calculate the CBAM coverage ratios, i.e., the percentage extent to which exporter countries' industries are exposed to CBAM, it is necessary to use more granular trade data. While the CBAM industry as outlined in the EU Commission proposal are defined at the CN 8-digit level (EUCOM (2021), Annex I), the OECD (2022b) nomenclature only contains broader industry aggregates. To bridge this gap, this paper proposes an industry conversion scheme to translate BACI trade data of 2014 at the HS 6-digit level (Gaulier and Zignago (2010)) to the industry aggregation scheme as in OECD (2022b). The industry aggregation scheme rests upon the conversion table "BTDIxEIndustries.pdf" according to OECD (2021).

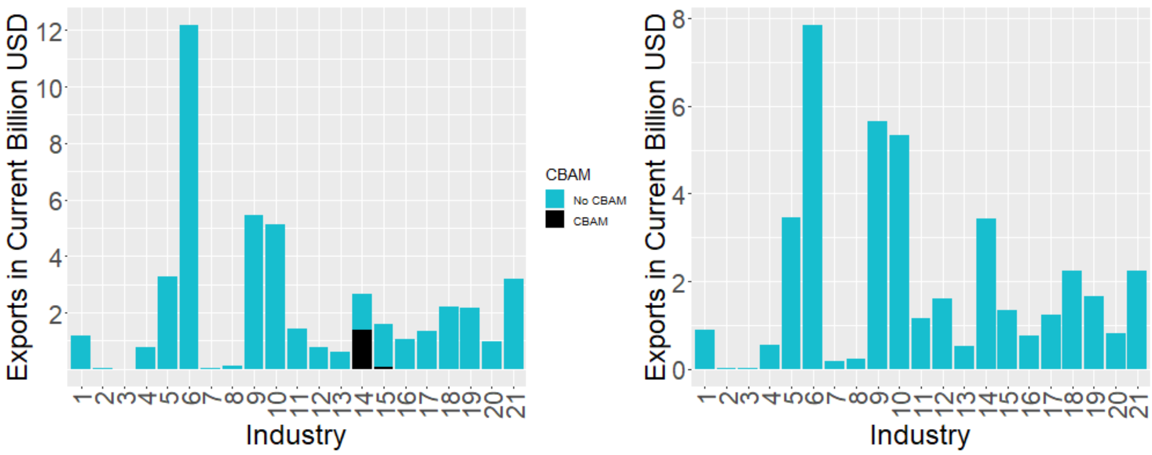

Fig. 6 *Left:* CBAM Coverage in Goods Exports from India to the EU in 2014. Sources: BACI (Gaulier and Zignago (2010)) for Export Data and OECD (2021) for the Conversion Scheme from UN Comtrade HS6 6-Digits to the ISIC4 Rev. 4 2-Digit Industry Aggregation. *Right:* Goods Exports from India to the EU in 2014. Source: OECD (2022b).

Figure B.1 compares the sector-level exports from India to the EU as to BACI export data (Gaulier and Zignago (2010)) and the baseline BAU equilibrium trade flows retrieved from the OECD ICIO tables (OECD (2022b)). To produce the left panel of Figure B.1, the HS6-to-ISIC Rev. 4 conversion scheme (OECD (2022b))) matches the HS6 codes of the BACI version 202401 trade flows (Gaulier and Zignago (2010)) to the OECD industry aggregation scheme which is used in the main analysis of this paper. There are some noteworthy differences between the sectoral decomposition of India's exports retrieved by different trade data. While according to the concorded BACI data, total goods exports from India to the EU make up 46 bn. USD in 2014, the BAU equilibrium data state 34 bn. USD. It is important to retain that using this industry conversion scheme might distort the results, to some extent.

B.3 The Role of the CBAM in India-EU Trade

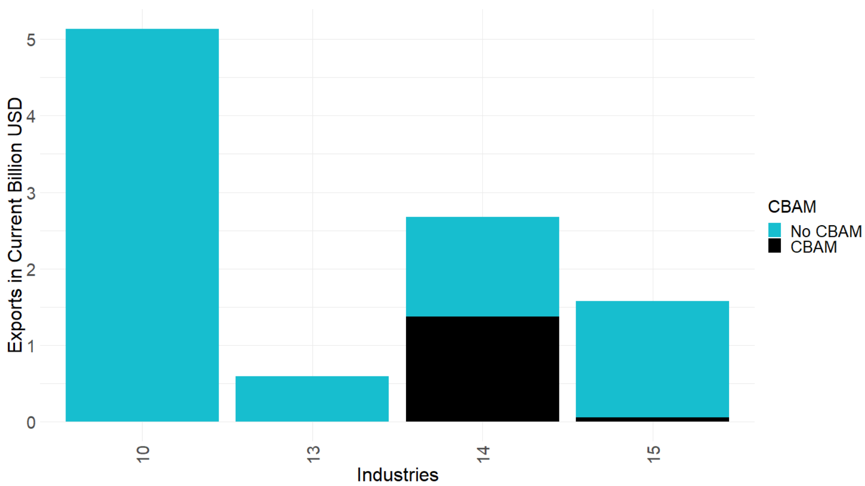

Fig. 7 CBAM Coverage in Goods Exports from India to the EU in 2014. Sources: BACI (Gaulier and Zignago (2010)) for the Export Data and OECD (2021) for the Conversion Scheme from UN Comtrade HS6 6-Digits to the ISIC4 Rev. 4 2-Digit Industry Aggregation.

Exploiting the sector-level detail the BACI data (Gaulier and Zignago (2010)) offer, Figure B.2 shows the coverage ratio of CBAM in India's exports to the EU by industries, in 2014. In 2014, 52% of India's basic metals aggregate (14) export value fell under the current CBAM, rendering it the highest within-industry coverage ratio among all Indian industries. In contrast, CBAM applies only to 5% of India's fabricated metals (15) exports, 0.04% of India's other non-metallic mineral products (13), largely made up by cement, and a mere 0.01% of India's chemicals products (10) export value, largely driven by fertilizers.

Compared to all other CBAM industries, the ratio of CBAM exposure across product groups of 87% in basic metals (14) and 9% in fabricated metal products (15), in 2014 are confirmed by Simola (2021) who estimates a share of 90% of India's CBAM exports in steel products, followed by 10% in aluminium, in 2019. In the BACI data, fertilizers and cement make up negligible shares (4% combined). According to the BACI data, India's total exports of CBAM goods to the EU make up 1.4 bn. USD in 2014, roughly resembling the estimate of 3 bn. EUR for 2019 obtained with Eurostat data (Simola (2021).

Considering these within-industry coverage ratios is crucial when interpreting the results. Under the current CBAM legislation, Indian chemicals exports are thus far less exposed to CBAM than assumed in the model. An extension to this study would apply the each within-industry CBAM coverage ratio to each sectoral CBAM tariffs. To arrive at the alternative BAU-CBAM tariffs, the CBAM tariffs would be multiplied with the CBAM coverage ratio within each OECD (2022b) industry aggregate. Moreover, BACI trade data might come in handy since they offer a more detailed picture of exports across product groups than do the industry aggregates as offered in the OECD ICIO tables (OECD (2022b)).

C Additional Results

C.1 Changes in Trade and CO2 Emissions

Exporter	Absolute Changes						Percentage Changes					
	BAU-CBAM		BAU-FTA		CBAM-FTA		BAU-CBAM		BAU-FTA		CBAM-FTA	
	All	Only Inter	All	Only Inter	All	Only Inter	All	Only Inter	All	Only Inter	All	Only Inter
ARG	-4	-4	-48	-48	158	158	0.000	-0.005	-0.005	-0.060	0.017	0.197
AUS	-24	-24	-118	-118	117	117	-0.001	-0.007	-0.004	-0.037	0.004	0.037
BRA	-119	-119	-283	-283	279	279	-0.003	-0.040	-0.007	-0.094	0.007	0.093
CAN	-37	-37	-309	-309	169	169	-0.001	-0.007	-0.010	-0.056	0.005	0.030
CHE	28	28	-558	-558	358	299	0.002	0.008	-0.039	-0.161	0.025	0.087
CHN	-1544	-1544	-5484	-5484	3630	3970	-0.005	-0.072	-0.019	-0.257	0.012	0.186
COL	-8	-8	-25	-25	81	80	-0.001	-0.011	-0.004	-0.034	0.012	0.110
CRI	0	0	-6	-6	22	31	0.000	0.001	-0.007	-0.034	0.026	0.183
EUN	9590	0	26629	72848	76920	83401	0.028	0.000	0.077	2.520	0.221	2.885
IDN	-131	-131	-385	-385	-110	-100	-0.008	-0.061	-0.023	-0.180	-0.007	-0.047
IND	-501	-501	-2628	56708	-48646	10978	-0.013	-0.104	-0.067	11.795	-1.236	2.283
JPN	-1007	-1007	-1856	-1856	-358	-480	-0.011	-0.109	-0.021	-0.201	-0.004	-0.052
KAZ	-36	-36	-7	-7	-40	13	-0.010	-0.053	-0.002	-0.011	-0.011	0.020
KOR	60	60	-1223	-1223	619	214	0.002	0.009	-0.035	-0.182	0.018	0.032
MAR	5	5	-684	-684	-474	-411	0.003	0.010	-0.379	-1.521	-0.262	-0.913
MEX	-99	-99	-199	-199	464	514	-0.005	-0.024	-0.009	-0.048	0.021	0.123
NOR	36	36	-121	-121	98	68	0.004	0.021	-0.014	-0.071	0.012	0.040
NZL	0	0	-18	-18	33	35	0.000	0.000	-0.005	-0.034	0.008	0.065
PER	2	2	-20	-20	96	105	0.001	0.005	-0.006	-0.043	0.030	0.224
ROW	-188	-188	-3971	-3971	-31650	-2761	-0.001	-0.008	-0.028	-0.160	-0.224	-0.111
RUS	-2567	-2567	-549	-549	-512	1783	-0.074	-0.530	-0.016	-0.113	-0.015	0.368
SAU	-235	-235	-534	-534	440	-50	-0.021	-0.080	-0.048	-0.182	0.040	-0.017
THA	-43	-43	-507	-507	-22	372	-0.004	-0.016	-0.052	-0.192	-0.002	0.141
TUR	-285	-285	-458	-458	1111	1071	-0.016	-0.126	-0.026	-0.203	0.064	0.475
TWN	-112	-112	-551	-551	226	309	-0.009	-0.033	-0.045	-0.163	0.018	0.091
USA	-2501	-2501	-6011	-6011	634	64	-0.008	-0.103	-0.020	-0.248	0.002	0.003
VNM	-18	-18	-157	-157	332	376	-0.003	-0.012	-0.030	-0.104	0.063	0.249
ZAF	-260	-260	-134	-134	712	819	-0.039	-0.235	-0.020	-0.121	0.106	0.741

Table 4 Counterfactual Exports under an EU CBAM (BAU-CBAM), an EU-India FTA (BAU-FTA), and an EU-India FTA under a CBAM (CBAM-FTA). All: Exports include Intra-Country Trade. Only Inter: only Exports Beyond the Country's Borders. Absolute Changes in Current Million USD.

Exporter	Absolute Changes						Percentage Changes					
	BAU-CBAM		BAU-FTA		CBAM-FTA		BAU-CBAM		BAU-FTA		CBAM-FTA	
	All	Only Inter	All	Only Inter	All	Only Inter	All	Only Inter	All	Only Inter	All	Only Inter
ARG	-0.001	-0.001	-0.003	0.000	0.000	0.000	-0.001	-0.006	-0.003	-0.027	0.000	-0.001
AUS	-0.006	-0.006	-0.020	-0.013	-0.013	-0.013	-0.002	-0.013	-0.006	-0.041	-0.004	-0.025
BRA	-0.042	-0.042	-0.020	-0.006	-0.006	-0.006	-0.011	-0.090	-0.005	-0.042	-0.002	-0.014
CAN	-0.003	-0.003	-0.038	-0.018	-0.018	-0.018	-0.001	-0.002	-0.008	-0.029	-0.004	-0.013
CHE	0.001	0.001	-0.016	-0.001	0.000	-0.001	0.002	0.007	-0.048	-0.164	-0.001	-0.009
CHN	-0.608	-0.608	-1.416	-0.894	-0.903	-0.894	-0.007	-0.153	-0.016	-0.356	-0.010	-0.225
COL	-0.001	-0.001	-0.003	-0.001	-0.001	-0.001	-0.002	-0.014	-0.004	-0.025	-0.001	-0.007
CRI	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.001	-0.003	-0.014	0.006	0.040
EUN	1.485	0.000	7.496	12.751	12.271	12.751	0.057	0.000	0.286	4.462	0.468	4.527
IDN	-0.026	-0.026	-0.102	-0.066	-0.067	-0.066	-0.006	-0.050	-0.025	-0.195	-0.017	-0.126
IND	-0.559	-0.559	-9.532	1.269	-13.114	1.269	-0.029	-0.339	-0.502	2.938	-0.691	0.769
JPN	-0.114	-0.114	-0.185	-0.079	-0.077	-0.079	-0.010	-0.140	-0.017	-0.227	-0.007	-0.097
KAZ	-0.067	-0.067	-0.007	0.001	-0.003	0.001	-0.038	-0.218	-0.004	-0.022	-0.002	0.003
KOR	0.009	0.009	-0.117	-0.065	-0.056	-0.065	0.002	0.012	-0.021	-0.156	-0.010	-0.087
MAR	-0.003	-0.003	-0.012	-0.008	-0.010	-0.008	-0.006	-0.051	-0.027	-0.220	-0.022	-0.148
MEX	-0.008	-0.008	-0.014	0.007	0.006	0.007	-0.002	-0.017	-0.004	-0.031	0.002	0.016
NOR	0.010	0.010	-0.047	-0.006	-0.006	-0.006	0.019	0.033	-0.087	-0.152	-0.010	-0.019
NZL	0.000	0.000	-0.004	-0.001	-0.001	-0.001	0.000	0.000	-0.014	-0.075	-0.004	-0.019
PER	0.000	0.000	0.000	0.002	0.002	0.002	0.000	-0.001	-0.001	-0.007	0.005	0.029
ROW	-0.033	-0.033	-1.041	-0.830	-0.981	-0.830	-0.001	-0.006	-0.032	-0.192	-0.030	-0.153
RUS	-5.517	-5.517	-1.227	-0.197	-0.225	-0.197	-0.395	-2.134	-0.088	-0.474	-0.016	-0.076
SAU	-0.111	-0.111	-0.389	-0.264	-0.189	-0.264	-0.023	-0.217	-0.080	-0.762	-0.039	-0.517
THA	-0.016	-0.016	-0.086	-0.043	-0.058	-0.043	-0.007	-0.036	-0.036	-0.194	-0.025	-0.097
TUR	-0.041	-0.041	-0.040	-0.001	-0.001	-0.001	-0.014	-0.107	-0.014	-0.105	0.000	-0.004
TWN	-0.032	-0.032	-0.116	-0.078	-0.080	-0.078	-0.013	-0.068	-0.046	-0.247	-0.031	-0.165
USA	-0.138	-0.138	-0.378	-0.122	-0.107	-0.122	-0.003	-0.057	-0.009	-0.155	-0.003	-0.050
VNM	-0.013	-0.013	-0.028	-0.016	-0.017	-0.016	-0.009	-0.045	-0.020	-0.097	-0.012	-0.054
ZAF	-0.934	-0.934	-0.028	-0.011	-0.011	-0.011	-0.226	-1.226	-0.007	-0.036	-0.003	-0.014

Table 5 Counterfactual CO2 Emissions under an EU CBAM (BAU-CBAM), an EU-India FTA (BAU-FTA), and an EU-India FTA under a CBAM (CBAM-FTA). All: Exports include Intra-Country Trade. Only Inter: only Exports Beyond the Country's Borders. Absolute Changes in Million Tons of CO2.

References

Aichele, R., Felbermayr, G., & Heiland, I. (2016). Going Deep: The Trade and Welfare Effects of TTIP. *Ifo Working Paper*, 219. https://www.ifo.de/en/publications/2016/working-paper/going-deep-trade-and-welfare-effects-ttip-revised

Ambec, S. (2022). The European Union's Carbon Border Adjustment Mechanism: Challenges and Perspectives. https://www.tse-fr.eu/publications/european-unions-carbon-border-adjustment-mechanism-challenges-and-perspectives

Balistreri, E. J., & Markusen, J. R. (2009). Sub-National Differentiation and the Role of the Firm in Optimal International Pricing. *Economic Modelling*, *26*(1), 47–62. https://doi.org/10.1016/j.econmod.2008.05.004

Balistreri, E. J., & Rutherford, T. F. (2012). Subglobal Carbon Policy and the Competitive Selection of Heterogeneous Firms. *Energy Economics*, *34*, S190–S197. https://doi.org/10.1016/j.eneco.2012.08.002

Barrows, G., & Ollivier, H. (2018). Cleaner Firms or Cleaner Products? How Product Mix Shapes Emission Intensity from Manufacturing. *Journal of Environmental Economics and Management*, *88*, 134–158. https://doi.org/10.1016/j.jeem.2017.10.008

Bellora, C., & Fontagné, L. (2022). EU in Search of a WTO-Compatible Carbon Border Adjustment Mechanism. *Available at SSRN 4168049*. https://doi.org/10.2139/ssrn.4168049

Bergin, D., Cheng, T., Gilbert, V., & Meijer, W. (2021). Perception of the Planned EU Carbon Border Adjustment Mechanism in Asia Pacific — An Expert Survey. *Regional Project Energy Security and Climate Change Asia-Pacific (RECAP)*, *Konrad-Adenauer-Stiftung e.V.* https://www.kas.de/en/web/recap/single-title/-/content/perception-of-the-planned-eu-carbon-border-adjustment-mechanism-in-asia-pacific-an-expert-survey

Bierbrauer, F., Felbermayr, G., Ockenfels, A., Schmidt, K. M., & Südekum, J. (2021). A CO2-Border Adjustment Mechanism as a Building Block of a Climate Club. https://www.ifw-kiel.de/publications/kiel-policy-brief/2021/a-co2-border-adjustment-mechanism-as-a-building-block-of-a-climate-club-16065/

Böhringer, C., Fischer, C., Rosendahl, K. E., & Rutherford, T. F. (2022). Potential Impacts and Challenges of Border Carbon Adjustments. *Nature Climate Change*, *12*(1), 22–29. https://doi.org/10.1016/j.enpol.2022.113175

Caliendo, L., & Parro, F. (2015). Estimates of the Trade and Welfare Effects of NAFTA. *The Review of Economic Studies*, *82*(1), 1–44. https://doi.org/10.1093/restud/rdu035

Copeland, B. R. (2021). Globalization and the Environment. *NBER Working Paper*, 575. https://doi.org/10.3386/w28797

Cosbey, A., Droege, S., Fischer, C., & Munnings, C. (2019). Developing Guidance for Implementing Border Carbon Adjustments: Lessons, Cautions, and Research Needs from the Literature. *Review of Environmental Economics and Policy*. https://doi.org/10.1093/reep/rey020

Cosbey, A., Mehling, M., & Marcu, A. (2021). Border Carbon Adjustments in the EU: Sectoral Deep Dive. *Available at SSRN 3817779*. https://doi.org/10.2139/ssrn.3817779

Costinot, A., & Rodríguez-Clare, A. (2014). Trade Theory with Numbers: Quantifying the Consequences of Globalization. In *Handbook of international economics* (pp. 197–261, Vol. 4). Elsevier. https://doi.org/10.1016/B978-0-444-54314-1.00004-5

Dechezleprêtre, A., & Sato, M. (2017). The Impacts of Environmental Regulations on Competitiveness. *Review of Environmental Economics and Policy*. https://doi.org/10.1093/reep/rex013

Dekle, R., Eaton, J., & Kortum, S. (2008). Global Rebalancing With Gravity: Measuring the Burden of Adjustment. *IMF Staff Papers*, *55*(3), 511–540. https://www.imf.org/external/pubs/ft/staffp/2008/03/dekle.htm

Dröge, S. (2021). Ein CO2-Grenzausgleich für den Green Deal der EU: Funktionen, Fakten und Fallstricke. https://doi.org/10.18449/2021S09

EUCOM. (2021). Proposal for a Regulation of the European Parliament and of the Council Establishing a Carbon Border Adjustment Mechanism. *COM/2021/564 final*. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52021PC0564

Felbermayr, G., Mitra, D., Aichele, R., & Gröschl, J. (2017). *Europe and India: Relaunching a Troubled Trade Relationship*. https://www.ifo.de/en/publications/2017/monograph-authorship/europe-and-india-relaunching-troubled-trade-relationship

Gallina, F., Parenti, M., & Vicard, V. (2020). Assessing the Potential Impact of an EU-India Trade Agreement: Cost of Non-Europe Report. *Cecilia Navarra, European Added Value Unit, DG EPRS*. https://www.europarl.europa.eu/thinktank/en/document/EPRS_STU(2020)642841

Garsous, Grégoire and Mateo, Mark and Teusch, Jonas and Theodoropoulos, Konstantinos and Tricaud, Astrid and Van Dender, Kurt. (2023). Net Effective Carbon Rates. https://doi.org/10.1787/279e049e-en

Gaulier, G., & Zignago, S. (2010). BACI: International Trade Database at the Product-Level. The 1994-2007 Version. *CEPII*, (2010-23). http://www.cepii.fr/CEPII/en/publications/wp/abstract.asp?NoDoc=2726

Gaurav, A., & Mathur, S. (2016). Trade Costs of India with the European Union and Growth Accounting of Trade. *Journal of Economics, Business and Management*, *4*(2), 149–154. https://doi.org/10.7763/JOEBM.2016.V4.382

Gros, D. (1987). A Note on the Optimal Tariff, Retaliation and the Welfare Loss from Tariff Wars in a Framework with Intra-Industry Trade. *Journal of international Economics*, *23*(3-4), 357–367. https://doi.org/10.1016/0022-1996(87)90061-4

Helpman, E., & Krugman, P. (1989). Trade Policy and Market Structure. *The MIT Press*. https://mitpress.mit.edu/9780262580984/trade-policy-and-market-structure/

Höslinger, E., Redl, S., & Bittó, V. (2022). *Analyse des Vorschlags der EU-Kommission zur Einführung eines CO2 Grenzausgleichs" CBAM"* (tech. rep.). https://www.econstor.eu/handle/10419/256798

Houser, T., Bradley, R., Childs, B., Werksman, J., & Heilmayr, R. (2008). *Leveling the Carbon Playing Field: International Competition and US Climate Policy Design*. Peterson Institute. https://www.piie.com/bookstore/leveling-carbon-playing-field-international-competition-and-us-climate-policy-design

Hufbauer, G. C., Schott, J. J., Hogan, M., & Kim, J. (2022). EU Carbon Border Adjustment Mechanism Faces Many Challenges. *Peterson Institute for International Economics Policy Brief*, (14). https://www.piie.com/publications/policy-briefs/eu-carbon-border-adjustment-mechanism-faces-many-challenges

Khorana, S., & Garcia, M. (2013). European Union-India Trade Negotiations: One Step Forward, One Back? *JCMS: Journal of Common Market Studies*, *51*(4), 684–700. https://doi.org/10.1111/jcms.12024

Korpar, N., Larch, M., & Stöllinger, R. (2023). The European Carbon Border Adjustment Mechanism: a Small Step in the Right Direction. *International Economics and Economic Policy*, *20*(1), 95–138. https://doi.org/10.1007/s10368-022-00550-9

Lanzi, E., Chateau, J., & Dellink, R. (2012). Alternative Approaches for Levelling Carbon Prices in a World with Fragmented Carbon Markets. *Energy Economics*, *34*, S240–S250. https://doi.org/10.1016/j.eneco.2012.08.016

Larch, M., & Wanner, J. (2017). Carbon Tariffs: An Analysis of the Trade, Welfare, and Emission Effects. *Journal of International Economics*, *109*, 195–213. https://doi.org/10.1016/j.jinteco.2017.09.003

Martin, L. A. (2011). Energy Efficiency Gains from Trade: Greenhouse Gas Emissions and India's Manufacturing Sector. *Mimeograph, Berkeley ARE*. https://arefiles.ucdavis.edu/uploads/filer_public/2014/03/27/martin-energy-efficiencynov.pdf

Melitz, M. J. (2003). The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity. *Econometrica*, *71*(6), 1695–1725. https://doi.org/10.1111/1468-0262.00467

Mörsdorf, G. (2022). A Simple Fix for Carbon Leakage? Assessing the Environmental Effectiveness of the EU Carbon Border Adjustment. *Energy Policy*, *161*, 112596.

Nordhaus, W. (2015). Climate Clubs: Overcoming Free-Riding in International Climate Policy. *American Economic Review*, *105*(4), 1339–1370. https://doi.org/10.1257/aer.15000001

OECD. (2021). Bilateral Trade in Goods by Industry and End-use (BTDIxE). https://stats.oecd.org/OECDStat_Metadata/ShowMetadata.ashx?Dataset=BTDIXE_I4&ShowOnWeb=true&Lang=en

OECD. (2022a). Net Effective Carbon Rates. *OECD Taxation Working Papers*. https://doi.org/10.1787/22235558

OECD. (2022b). OECD Inter-Country Input-Output (ICIO) Tables. http://oe.cd/icio

OECD. (2022c). Trade in Embodied CO2 (TECO2) Database. https://www.oecd.org/sti/ind/carbondioxideemissionsembodiedininternationaltrade.htm

Overland, I., & Sabyrbekov, R. (2022). Know Your Opponent: Which Countries Might Fight the European Carbon Border Adjustment Mechanism? *Energy Policy*, *169*, 113175. https://doi.org/10.1016/j.enpol.2022.113175

Payosova, T., Redelbach, J., & Notani, S. (2022). The EU Carbon Border Adjustment Mechanism – Implications for India. *Economic Law Practice*. https://elplaw.in/leadership/the-eu-carbon-border-adjustment-mechanism-implications-for-india/

Shapiro, Joseph S. (2021). The Environmental Bias of Trade Policy. *The Quarterly Journal of Economics*, *136*(2), 831–886. https://doi.org/10.1093/qje/qjaa042

Simola, H. (2021). CBAM!–Assessing Potential Costs of the EU Carbon Border Adjustment Mechanism for Emerging Economies. https://urn.fi/URN:NBN:fi:bof-202110252070

Timmer, M. P., Dietzenbacher, E., Los, B., Stehrer, R., & De Vries, G. J. (2015). An Illustrated User Guide to the World Input-Output Database: the Case of Global Automotive Production. *Review of International Economics*, *23*(3), 575–605. https://doi.org/10.1111/roie.12178

UN. (2023). UNTRAINS Database. https://trainsonline.unctad.org/home

Zhong, J., & Pei, J. (2022). Beggar thy neighbor? On the Competitiveness and Welfare Impacts of the EU's Proposed Carbon Border Adjustment Mechanism. *Energy Policy*, *162*, 112802. https://doi.org/10.1016/j.enpol.2022.112802