CARBON BORDER ADJUSTMENT MECHANISM (CBAM): IMPACT ON INDIA'S STEEL EXPORTS TO THE EU AND CARBON TAX INCIDENCE

AMRITA GOLDAR
BISHWANATH GOLDAR
KUMAR ABHISHEK
SUNISHTHA YADAV
POULOMI BHATTACHARYA

JUNE 2026

433
WORKING PAPER

Table of Contents

Abstract i

Acknowledgment i

1. Introduction 1

2. India in Global Iron and Steel (I&S) Trade 2

2.1 India in Global I&S Trade: Product Composition 3

2.2 India in Global I&S Export: Product Composition 4

2.3 India in Global I&S Import: Product Composition 4

3. India's Trade with the EU 5

4. Carbon-Linked Trade Measures: Policy and Economic Perspectives 8

4.1 Objectives and Design of the EU-CBAM 8

4.2 Trade Tensions and Decarbonization Implications 8

5. Modelling Approaches in Literature and Findings of Earlier Studies 9

6. Methodology of the Present Study and Empirical Results 11

*6.1 ICRIER's **'Samriddhi'** Trade Computable General Equilibrium (CGE) Model* 11

*6.1.1 Modelling Carbon Tariff in the **'Samriddhi'** CGE Model* 12

6.2 Modelling CBAM 12

6.2.1 Identifying CBAM Sectors 12

6.2.2 Identifying CBAM Regions 12

6.2.3 Calculating the CBAM Levy 13

7. The Results 13

7.1 Impact on GDP and Trade 13

7.2 Impact on Carbon Emission 15

8. Conclusion 17

References 19

APPENDIX 23

List of Tables

Table 1: Mapping CBAM commodities and GTAP sectors 12

Table 2: Yearly average EU Carbon Permit Price (USD) 13

Table 3: CBAM Impact on trade: EU imports from the World and India 14

Table 4: CBAM Impact on China and India's Export of I&S in Different Markets (% Changes) 14

Table 5: CBAM Impact on carbon emissions: By fuel 16

Table 6: Percent change in carbon intensity in the I&S industry in different countries 16

Table 7: Percent change in CO_2 emissions by the I&S industry in major steel-producing countries: By Fuel products 17

List of Figures

Figure 1: India's production and consumption of finished steel (2017-22) 3

Figure 2: India in global I&S: Exports (2017-22) 3

Figure 3: India in global I&S: Export Product Composition (2021) 4

Figure 4: India in global I&S: Import Product Composition (2021) 5

Figure 5: India's trade with EU (2017-2022) 5

Figure 6: India's exports of CBAM commodities (2017-22) 6

Figure 7: CBAM commodities in India's export basket (2017-22) 6

Figure 8: CBAM commodity composition in India's export to the EU for 2022 7

Figure 9: I&S export to EU: Composition (2017-22) 7

Figure 10: EU Carbon Permits (EUR) 13

Abstract

The iron and steel (I&S) sector provides key inputs for vehicles, construction, and machinery materials. Global steel production is increasing, with the world's share of steel exports falling to 22%. Since this sector also accounts for about 8% of the total emissions, numerous major steel-producing countries have implemented policy initiatives to decarbonize the steel sector.

As a net steel importer, the European Union (EU) has taken measures to limit domestic carbon emissions through stringent commitments. Since international trade of goods contributes to about 27% of global CO_2 emissions, the EU intends to control embedded emissions from imported goods. This is proposed through the Carbon Border Adjustment Mechanism (CBAM) as part of the European Green Deal, a component of the 'Fit for 55' package. However, this mechanism could negatively affect the growth and trade prospects of developing economies like India, a net steel exporter with a diversified supply chain. This impact depends on the extent of substitution possible by the EU and other countries for Indian steel exports.

The present study is undertaken by applying the ICRIER ***Samriddhi*** Model (GTAP-E based), which evaluates the impact of the imposition of CBAM on India's steel exports, thus indicating a pathway India should adopt if the EU imposes a carbon border tax. The study results indicate that CBAM is likely to significantly impact India's steel exports to the EU, causing a fall in India's steel exports to the EU by 24%. The paper also gauges whether the imposition of CBAM would lead to a significant reduction in carbon emissions and finds that a reduction of 1% in aggregate emissions will occur in the global steel industry.

Acknowledgment

The authors thank Dr. Deepak Mishra (Former Director and Chief Executive of ICRIER) for his constant support and encouragement. We also thank Mr. Devender Pratap, Prof. Sanjib Pohit, and Dr. Badri Narayanan Gopalakrishnan for their guidance during this study.

Keywords: *CBAM, International trade, Industrial decarbonization, Steel exports.*

JEL classification: *F18, Q37, L52*

Authors' email: *agoldar@icrier.res.in; b_goldar77@yahoo.com; kabhishek@icrier.res.in; sunishtha9185yadav@gmail.com; poulomi.ju.eco@gmail.com*

Carbon Border Adjustment Mechanism (CBAM): Impact on India's Steel Exports to the EU and Carbon Tax Incidence

Amrita Goldar[1], Bishwanath Goldar[2], Kumar Abhishek[3], Sunishtha Yadav[4], and Poulomi Bhattacharya[5]

1. Introduction

IPCC's Synthesis Report, 2023 (AR6 SYR), using different modelled pathways, shows that if global warming continues at the same pace, it will be difficult to restrict the temperature increase to 2°C by the 21st century. The report highlights the need to curtail human-induced global warming by the goals outlined in the Paris Agreement on climate change, which necessitates reducing carbon dioxide emissions, especially in the hard-to-abate sectors.

The iron and steel (I&S) sector, representing the aforementioned hard-to-abate sectors, provides vital inputs for making buildings, infrastructure, vehicles, and machinery. Worldwide steel production is on the rise due to the increasing global demand, even as China's steel demand experiences a decline (World Steel Association, 2021). To keep up with the demand, by 2021, approximately a quarter of the global steel production, equating to 458 million tonnes, was being exported internationally (WTO, 2022). Given that the I&S sector is a significant contributor to global emissions (around 8% of the global total) (WTO, 2022), tracking and addressing emissions throughout the various stages of the steel industry, both upstream and downstream, presents a complex challenge for this sector, especially when compared to other industries that are also difficult to decarbonise.

As per the World Steel Association Report, 2021, the global export share of steel in 2020 has declined drastically to 22.9%, much lower than the levels seen a decade or a two earlier (29.4 % in 2010 and 39.2% in 2000). While global steel exports declined from 466.7 million tonnes in 2016 to 382.3 million tonnes in 2020, the global exports of products crafted from steel increased over the same period. Exports for products like ingots, semi-finished material, and railway track material increased over the said period from 54.3 million tonnes to 56.9 million tonnes and from 3.1 million tonnes to 4.4 million tonnes, respectively. For steel tubes and fittings (37.2 million tonnes in 2016 to 32.5 million tonnes in 2020), wheels and axles (1.0 million tonnes in 2016 to 0.7 million tonnes in 2020), galvanized sheet (45.0 million tonnes in 2016 to 37.1 million tonnes in 2020) and other coated sheet (18.8 million tonnes in 2016 to 18.1 million tonnes in 2020), bars and rods, hot-rolled (40.3 million tonnes in 2016 to 12.8 million tonnes in 2020), hot-rolled sheets and coils (86.1 million tonnes in 2016 to 75.2 million tonnes), cold-rolled sheets and coils (35.6 million tonnes in 2016 to 18.2 million tonnes in 2020), wire rod (30.3 million tonnes in 2016 to 25.3 million tonnes in 2020), etc., the export shares in trade have declined. For castings and forgings, the export share has remained relatively stagnant from 2016 to 2020 (World Steel Association, 2021).

As of 2020, China, Russia, Japan, South Korea and the European Union[6] (EU) (particularly Germany) were the top exporters of steel in world trade (World Steel Association, 2021). India stood at the 8th position as a major steel exporter, accounting for 17.1 million tonnes in 2020, with the USA in the 20th position. China also holds the first position as a major importer of steel (37.9 million tonnes in 2020), followed by the EU (32.6 million tonnes in 2020). Overall, China holds a fifth position as a net exporter of steel, and the EU comes up as a net importer, accounting for 10 million tonnes in 2020, holding third position in the world steel trade. India had the sixth position in 2020, accounting for 12.1 million tonnes as a net steel exporter in world trade.

---

1 Professor, Indian Council for Research on International Economic Relations, New Delhi agoldar@icrier.res.in
2 Non-Resident Senior Fellow, Institute of Economic Growth, b_goldar77@yahoo.com, bgoldar49@iegindia.org
3 **Corresponding Author.** Consultant, Indian Council for Research on International Economic Relations, New Delhi kabhishek@icrier.res.in
4 **Former Research Associate,** Indian Council for Research on International Economic Relations, New Delhi sunishtha9185yadav@gmail.com
5 Postdoctoral Fellow, IIT Kanpur
6 For this study EU refers to the group of 27 countries, commonly referred to as EU27. For complete list please see https://trade.ec.europa.eu/access-to-markets/en/glossary/eu-27

As per the World Steel Association (2023) report, the EU produced 136.3 million tonnes of crude steel. The report shows that the monthly crude steel production has fallen below 10 million tonnes from 2019 to 2022. While the EU's share in world steel production has fallen from 10.2% in 2012 to 7.2% in 2022, India's share has risen from 4.9% in 2012 to 6.6% in 2022. In 2022, the EU became the major net importer of steel, with 22 million tonnes. India holds a seventh position as a net exporter of steel (5.2 million tonnes), preceded by China, Japan, Russia, South Korea, Brazil, and Oman.

As per World Trade Integrated Solution (WITS) data, in 2022 the EU imported 239.5 billion USD of I&S. Of this, Germany accounts for the highest share (14% of the total steel imports) of the value of steel imports to the EU, followed by Italy (9%), France (7.58%), Belgium (7.11%), and the Netherlands (5.15%). India ranks 15th, capturing 2.4% of the total value of I&S imports to the EU.

To reduce carbon emissions, many major steel-producing countries have undertaken policy initiatives to decarbonize the steel sector. In their policy brief, Goldar et al. (2023) undertake an in-depth study of the major steel-producing countries' policies and evaluate India's stance on decarbonizing the sector. The aforementioned policy brief not only highlights the key policy prescriptions that India should follow for the supply-side, demand-side, and export promotion strategies to produce low-carbon steel and remain competitive amongst the major steel producers but also identifies key issues that India ought to focus on to reach its Net-Zero targets by 2070. The study finds technological innovations followed by energy efficiency, labelling, and green procurement to be preferred policy instruments from the demand and supply side. This aligns with the roadmap that the IEA (2020) prescribes for the decarbonization of the global steel sector by 2050.

Taking the specific case of the EU, a net steel importer, the region has made firm commitments towards climate sustainability. It plans to introduce a Carbon Border Adjustment Mechanism (CBAM) to ensure it meets the requirements for a climate-neutral EU by 2050 and lower global carbon emissions by controlling carbon leakages (planned to be implemented in 2026). Nonetheless, this mechanism might impede the growth of trade opportunities for the developing nations, potentially serving as a protectionist tactic. Historical evidence demonstrates that such protectionist strategies have not yielded favourable outcomes for global exports and economic prosperity, thus negatively impacting nations. India, a significant net steel exporter with a diverse supply chain, could experience detrimental effects on its trade patterns and regional income due to the EU's implementation of carbon border taxes.

Research Objective

The present study aims to:

- Evaluate the impact of the EU's CBAM on India's steel and other energy-intensive exports to the EU.
- Examine the implications of CBAM for EU domestic steel supply, international trade flows, and imports from major steel-producing countries.
- Assess the potential of CBAM to drive meaningful reductions in global CO_2 emissions in the steel sector.

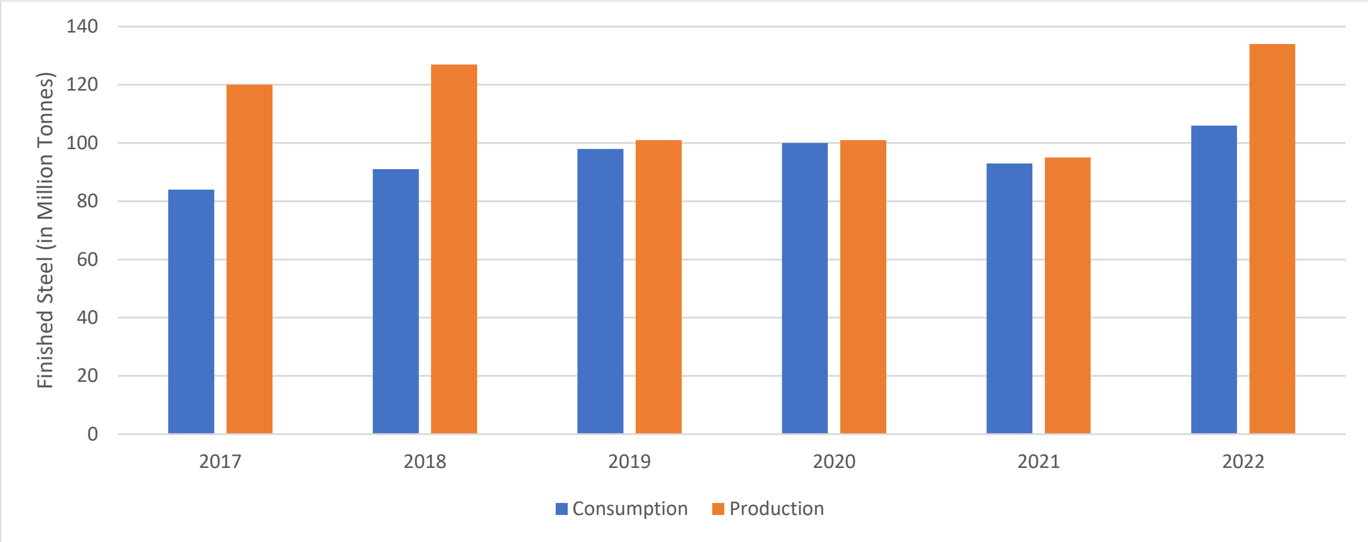
2. India in Global Iron and Steel (I&S) Trade

India's steel production capacity has increased rapidly over the last five years, from 122 million tonnes (MT) in 2016 to 143.9 MT in 2021, which translates into a CAGR of 3.9%. The National Steel Policy aims for a production capacity of up to 300 MT by 2030-31. The need for sustained growth in production capacity stems from sustained growth in steel consumption by sectors such as construction, infrastructure, engineering and packaging, and automotive. In 2020, construction and infrastructure alone accounted for 70% of total consumption (Statista, 2022).

7 National Steel Policy available on https://steel.gov.in/sites/default/files/draft-national-steel-policy-2017.pdf

8 Refer to https://www.statista.com/statistics/1170736/india-demand-share-for-steel-by-sector/

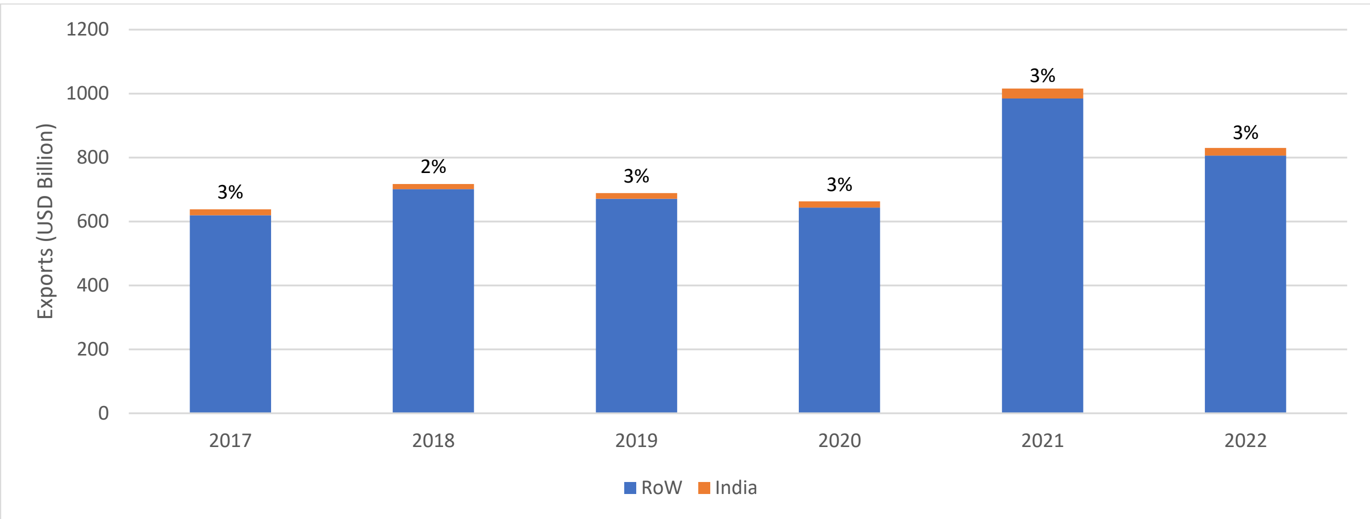
Figure 1: India's production and consumption of finished steel (2017-22)



Data Source: Joint Plant Committee, Ministry of Steel

Accompanied by the sustained production and consumption is the consistency in I&S exports from India. India's total value of I&S exports[9] for 2022 stood at USD 25 billion, about 3% of the total global exports, making it a significant contributor to global trade in I&S. Over the five years, from 2017 to 2022, global I&S exports have grown at a CAGR of 5% with some fluctuations. Korea, China, and Japan are the major import destinations of finished steel from India; in 2021, their share stood at 75% of the total (IBEF, 2023).

Figure 2: India in global I&S: Exports (2017-22)



Data Source: World Integrated Trade Solution (WITS), World Bank

2.1 India in Global I&S Trade: Product Composition

The product codes relevant to the I&S sector are spread across 4 chapters of the HS classification – Chapters 26, 28, 72, and 73. However, Chapters 72 and 73 are the most relevant, as they relate to iron and steel and the products made from them[10]. These identified codes correspond to mainly 3 Global Trade Analysis Project (GTAP) sectors: mining extraction (oxt), iron and steel: basic production and casting (i_s), and manufacturing of fabricated metal

9 For the purpose of identifying relevant HS codes which correspond to I&S products, reference has been made to Kowalski and Legendre (2023) and Aguiar (2016).

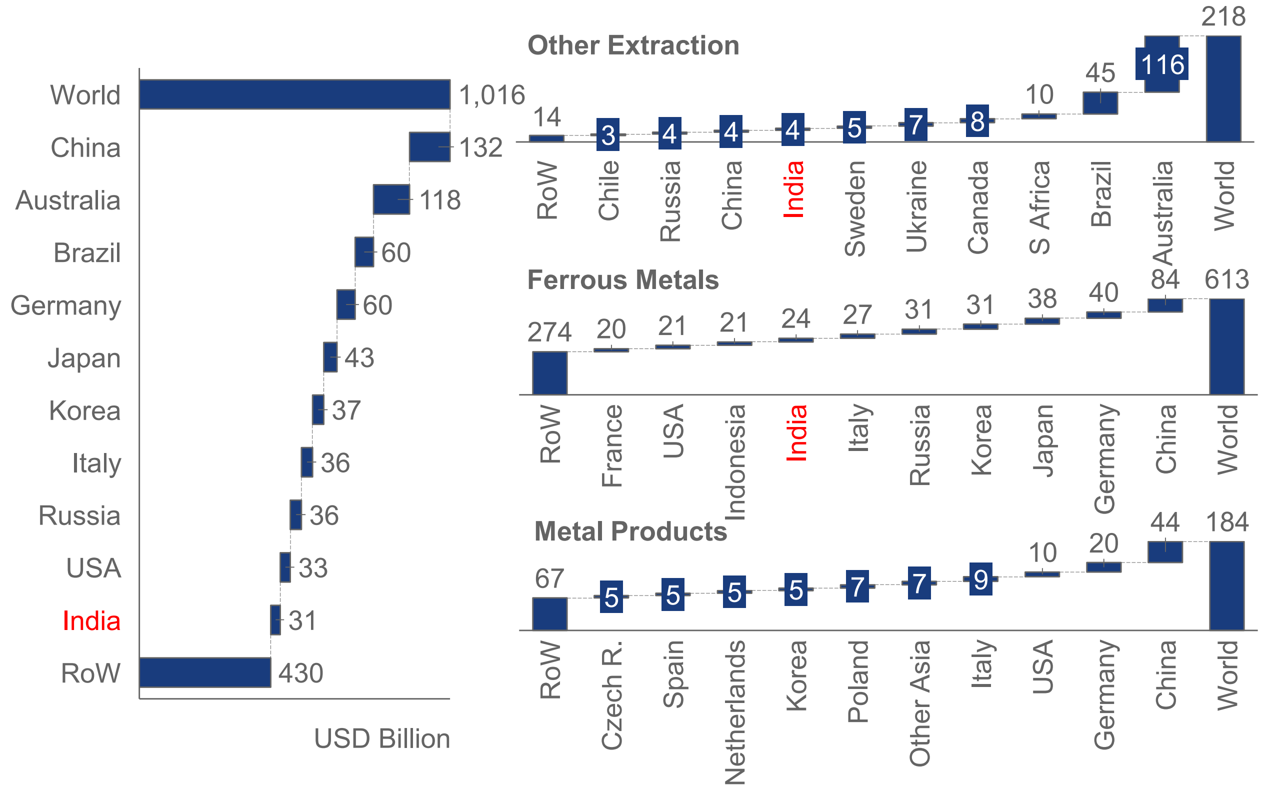
10 The detailed product codes are available at the https://www.wcoomd.org/en/topics/nomenclature/instrument-and-tools/hs-nomenclature-2017-edition/hs-nomenclature-2017-edition.aspx

products (fmp). These sectors can be classified into three categories based on their end use. The oxt sector provides the critical raw materials for the production of steel; it includes the extraction and mining of raw iron ore, i_s sector produces products such as pipes, sheets, rods, and basic structures, which serves as inputs for the production in other industries and finally, the fmp sector is associated with the production of final products made of I&S.

2.2 India in Global I&S Export: Product Composition

Of the three identified GTAP sectors, 21% of exports were from the mining sector (oxt), followed by 18% from metal products (fmp) and 60% from ferrous metals (i_s). Thus, the trade of intermediate products made of I&S dominates the trade landscape.

Figure 3: India in global I&S: Export Product Composition (2021)



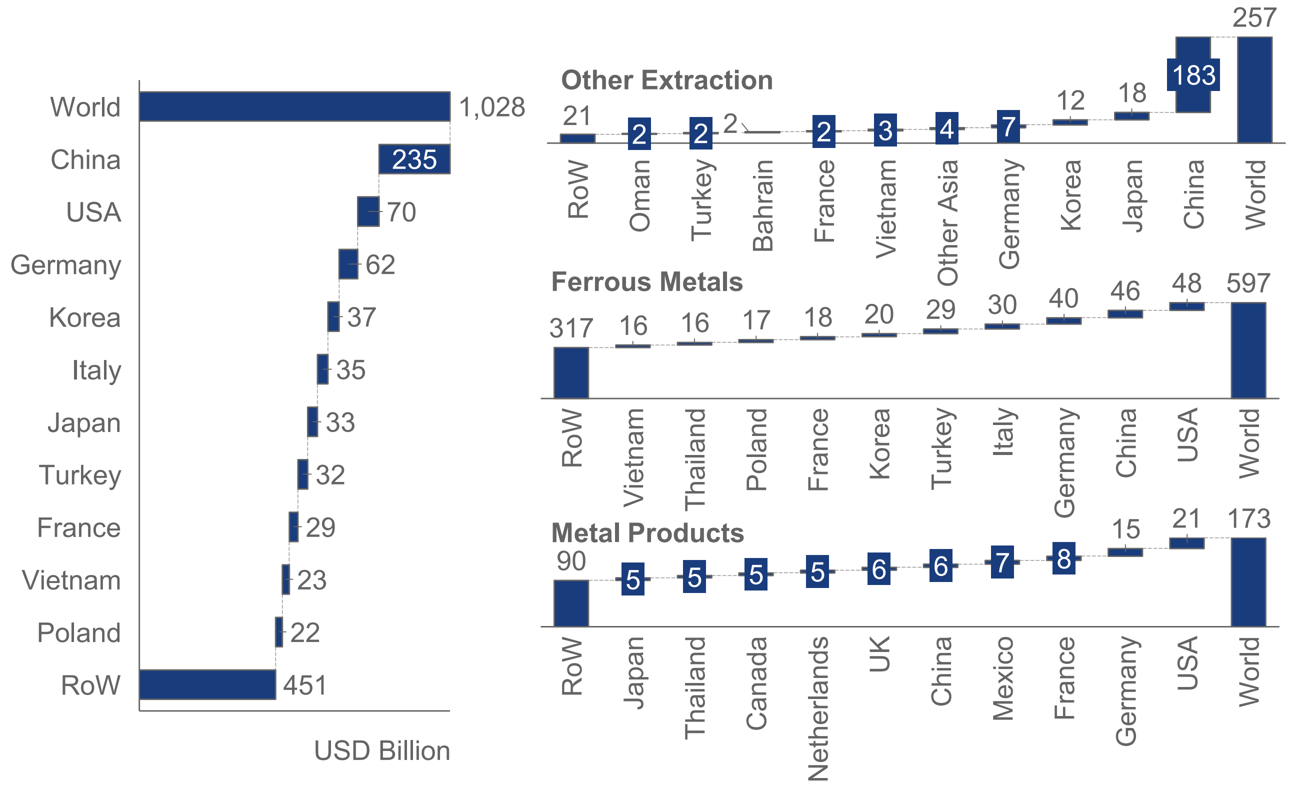
Data Source: World Integrated Trade Solution (WITS), World Bank

Global I&S exports in 2021 were 1,016 USD billion, approximately 12% each from China and Australia. India's global ranking stood at 10, with an export value of 31 USD billion. However, the decomposition of the exports based on product end use shows distinct trade patterns. The dominance of China in the global I&S trade is due to the export of ferrous metals and metal products made of I&S. Australia's iron ore export makes it a leading exporter of I&S. While India is among the top ten countries in terms of export of ferrous metals and iron ore, it lags in terms of metal products made of I&S.

2.3 India in Global I&S Import: Product Composition

The top 10 importers of I&S accounted for 56% of the total global imports of 1028 USD billion in 2021. Amongst the top 10 importers of I&S, China is the leading importer, with a 23% share (235 USD billion) in global imports in 2021. Germany, Italy, France, and Poland are among the top 10 importers in the EU. The EU accounts for 29% (298.54 USD billion) of total imports as a bloc.

Figure 4: India in global I&S: Import Product Composition (2021)



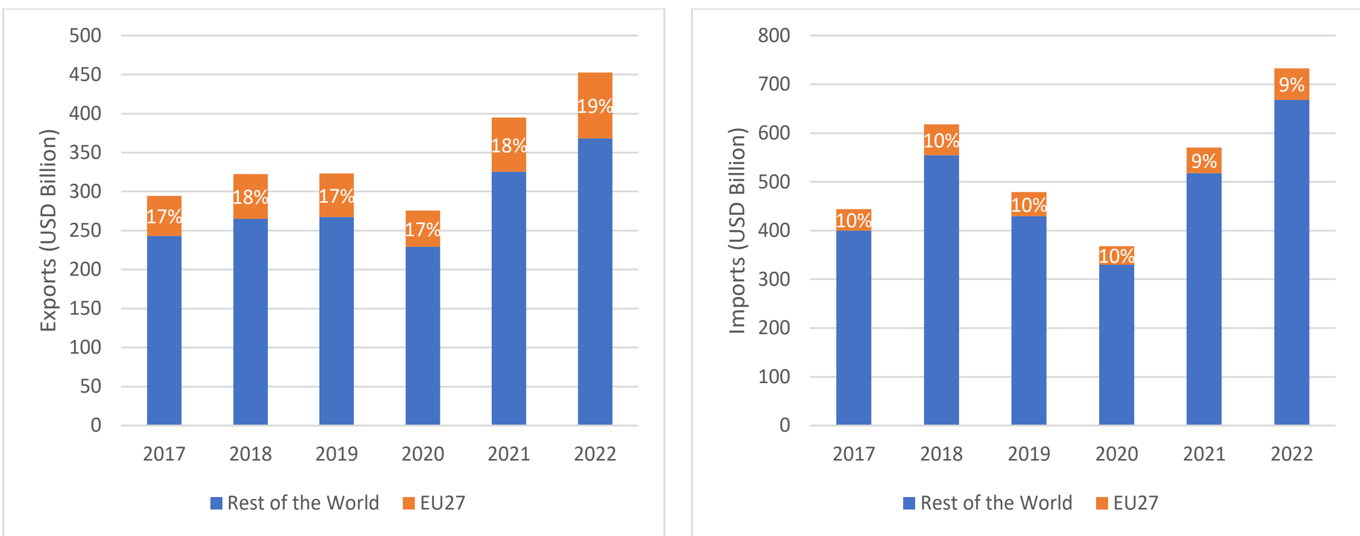
Data Source: World Integrated Trade Solution (WITS), World Bank

The product composition of global imports shows that China has a dominant presence, with a share of 70% of iron ore imports, mainly from Australia. The USA is the leading importer of ferrous metals and metals products, followed by Germany.

3. India's Trade with the EU

The EU, which comprises 27 European countries, is a key trading partner of India as 17-19% of India's exports are destined for the EU. The corresponding share in India's imports stands between 9-10%. The CAGR of exports from India to the EU from FY17 to FY22 was 8.76%, which is higher than the average CAGR of exports from India to the world, i.e., 7.44%. The balance of trade is in favour of India as the net exports are positive. For FY22, the net exports from India to the EU were 20.38 USD billion.

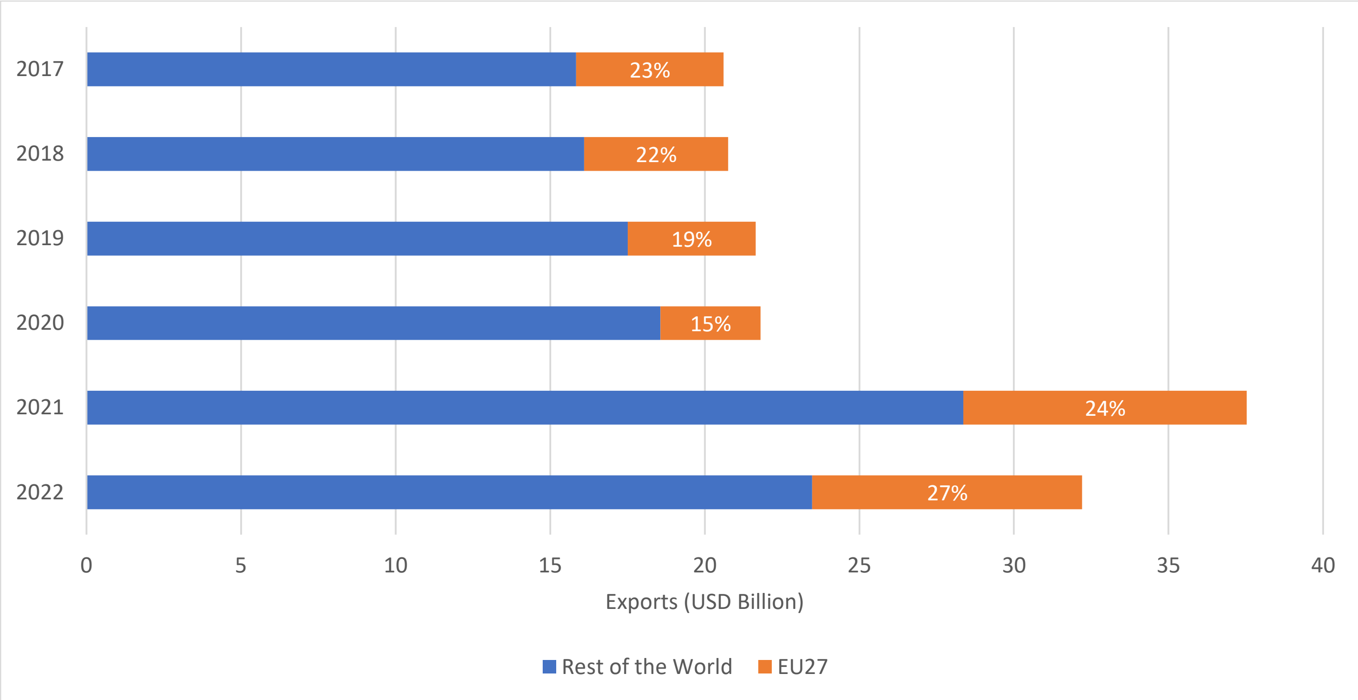
Figure 5: India's trade with the EU (2017-2022)



Data Source: World Integrated Trade Solution (WITS), World Bank

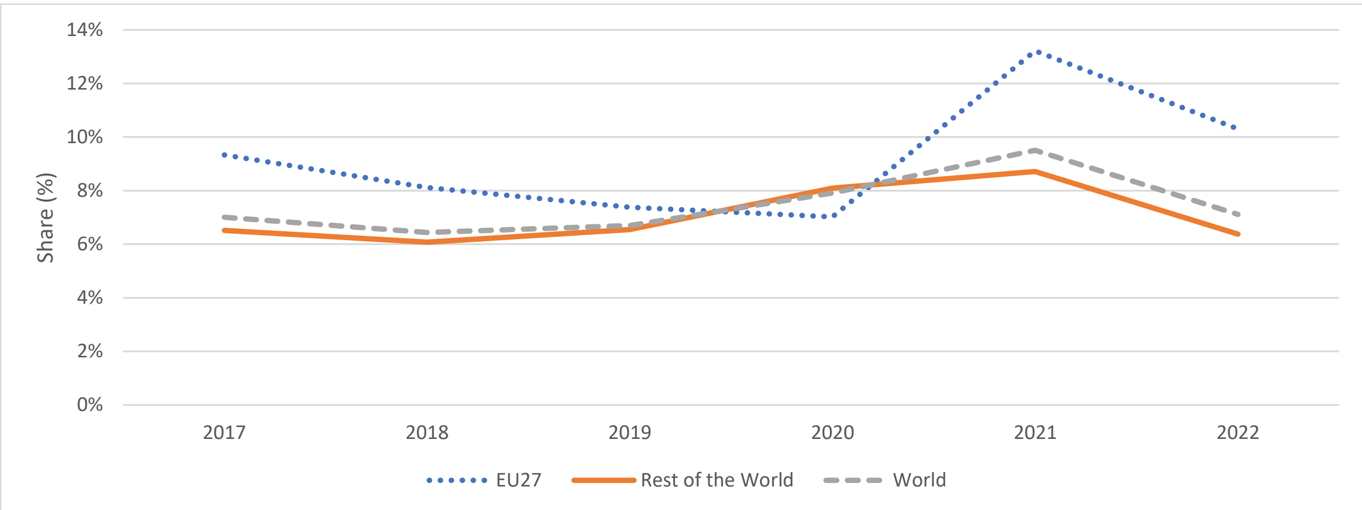
The CBAM commodities are the set of commodities subject to the EU CBAM during the initial phase; they include cement, I&S, aluminium, fertilizers, electricity, and hydrogen. India's total exports of CBAM commodities stood at 32.2 USD billion in 2022, of which 27% was to the EU. The share of CBAM commodities within India's total exports to the EU has averaged 9%, while for the RoW, the corresponding number is 7%. Thus, the CBAM commodities hold relatively higher importance in the export basket from India to the EU than from India to the world excluding the EU.

Figure 6: India's exports of CBAM commodities (2017-22)



Data Source: World Integrated Trade Solution (WITS), World Bank

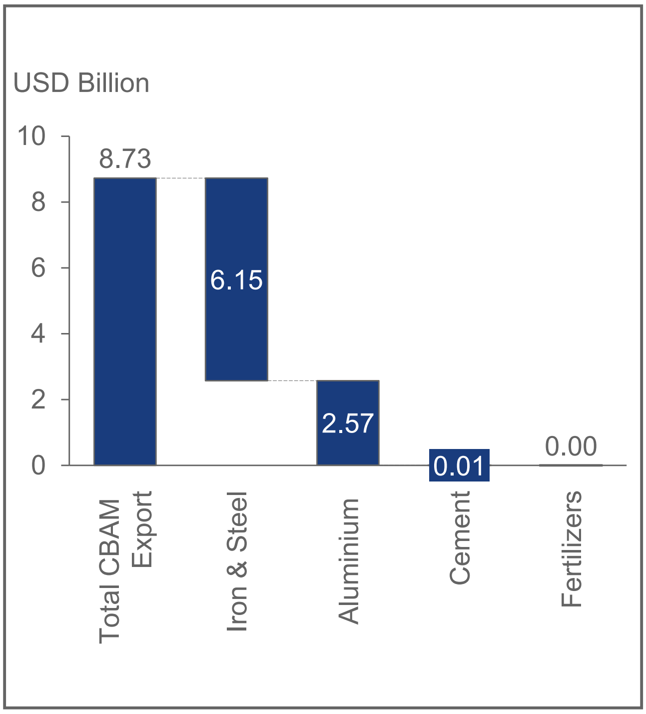
Figure 7: CBAM commodities in India's export basket (2017-22)



Data Source: World Integrated Trade Solution (WITS), World Bank

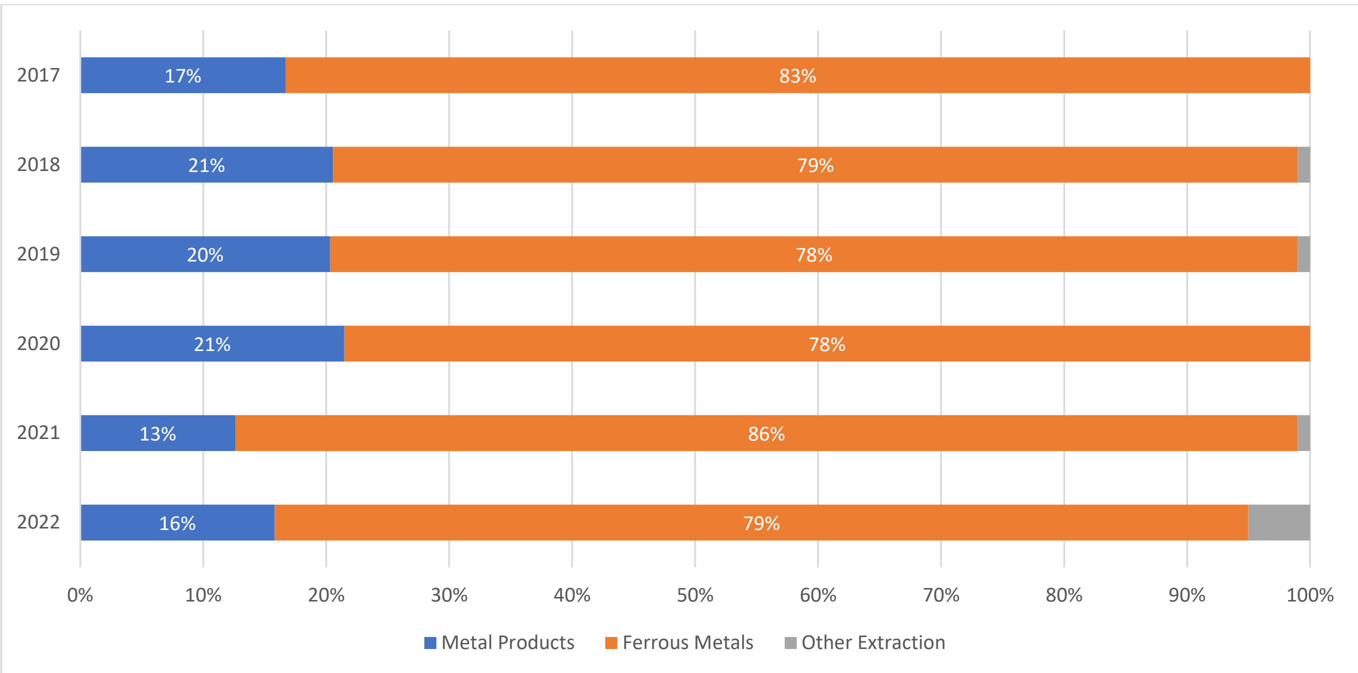
Among the CBAM commodities exported from India to the EU, the metal commodities dominate this export basket, comprising 70% of I&S and 29% of aluminium, respectively. Within the I&S commodity export to the EU, the products that serve as the intermediate input to other industries are dominant. It includes rods, wire, bars, and sheets of I&S of varying composition and thickness.

Figure 8: CBAM commodity composition in India's exports to the EU for 2022



Data Source: World Integrated Trade Solution (WITS), World Bank

Figure 9: I&S export to EU: Composition (2017-22)



Data Source: World Integrated Trade Solution (WITS), World Bank

4. Carbon-Linked Trade Measures: Policy and Economic Perspectives

4.1 Objectives and Design of the EU-CBAM

The EU has proposed CBAM as a climate-induced trade measure that taxes imports of goods based on the embedded carbon content.

International goods trade accounts for around 27% of global carbon dioxide emissions (Council of the EU, 2022). While the EU has restricted its domestic carbon emissions through strict commitments, it aims to control embedded emissions from imported goods by announcing CBAM in the European Green Deal as an element of the 'Fit for 55' package. The mechanism will come into force in 2026, although it will start monitoring the carbon content from countries in October 2023. It covers sectors, namely, I&S, refineries, cement, aluminium, organic basic chemicals, hydrogen, and fertilizers. It exempts countries like Norway, Switzerland, Iceland and Liechtenstein from its coverage as they are participate in EU ETS.

Imposing prices on imported goods based on their embedded carbon content ensures exempting some countries with stricter climate policies ensures that carbon-intensive goods produced by countries with relatively lax climatic conditions do not enter the EU markets. It also restricts the shift of product value chains of carbon-intensive goods to these countries with lesser climate-ambitious policies, thus controlling carbon leakage. The countries must purchase CBAM certificates at a price derived from the Emission Trading markets in the EU (EU ETS). They would pay the difference between domestic carbon prices and EU prices. This mechanism ensures that the domestic carbon prices in importing and exporting countries are equalized and that countries are encouraged to adopt climate-sustainable policies. This mechanism aims to gradually phase out the free ETS allowances provided by the EU government. The exemption of some countries from the CBAM proposal questions WTO's Most-Favored-Nation (MFN) principle (Majumder et al., 2024).

4.2 Trade Tensions and Decarbonization Implications

Climate-linked border measures may operate like tariffs and can trigger retaliatory reactions, potentially escalating into trade wars. Higher import costs increase domestic prices and reduce import demand, leading to a downfall in the demand for goods from the concerned exporting country. This creates trade tension between the concerned countries, which induces retaliatory actions from the exporting country and impacts the global supply chain through the upstream and downstream sectors. While some countries may temporarily gain, these advantages are often short-lived. Over the medium term, increased uncertainty reduces investor confidence, particularly in developing economies (Freund et al., 2018), which could be improved by strengthening their commitments towards WTO and regional trade agreements. The developing economies are the ones highly impacted by these actions as the benefits from the imposition of tariffs would depend on the terms of trade and income effects. Meanwhile, evidence from the US-China trade war shows heterogeneous impacts across Asia (Chadha et al., 2021). It shows that India initially gained in terms of GDP, exports, and imports from the US-China trade war but lost once they were also subject to higher tariffs by both countries. India would lose more if it adopted a retaliatory measure of increasing import tariffs. On the contrary, measures like reducing their import tariffs, joining a trade bloc like RCEP, and improving port, trade, and transport efficiency would benefit India while engaging in the trade war.

Therefore, history shows that increasing tariffs or trade restrictions[11], irrespective of the objective of imposition, are associated with trade wars and adversely impact all, especially developing economies. These tensions also disturb environmental sanctity, thus increasing global emissions. Thus, there is a concern whether CBAM is one such similar trade restriction introduced under the guise of climate consciousness. A few studies, e.g., Majumder et al. (2024), Aguiar et al. (2022), Zhong and Pei (2022), and UNCTAD (2021) argue that the CBAM implementation will not have

11 Other illustrations of the trade war are the EU's sanctions on Russia as part of the 11th package of sanctions against Russia (European Commission, 2023a; EUROMETAL, 2023) and China's economic sanctions on some products in Australia in 2020, like wine, barley, coal, lobsters, timber, red meat, and cotton (Reuters, 2022) restricting trade with (imports from and exports to) the country.

substantial impacts on global emissions and thus its objective remains unaccomplished mainly. It is implied that the EU will use this mechanism as a revenue-generating strategy by putting a price on imports with carbon content to recoup the benefits and recycle it only for the EU's development. Thus, in the dearth of consolidating finances for adopting climate-friendly technologies, this mechanism provides no benefit to developing countries if these revenues are not recycled among other needs of countries, thus creating a vicious cycle of climate poverty. Thus, implementing the CBAM proposal is viewed more as a protectionist strategy over climate sustainability measures. The following section summarizes the different CBAM impacts evaluated by different studies.

5. Modelling Approaches in Literature and Findings of Earlier Studies

Different approaches have been adopted in the literature to understand the impact of the CBAM. However, its impact remains ambiguous. Kuik and Hofkes (2010) also argue that the impact of imposing a carbon tariff by the US and EU on developing economies is ambiguous, although it reduced carbon emissions.

Sharma and Gupta (2023) have studied, in great depth, the impact of the implementation of CBAM on different trade and environmental parameters. Using case studies and data from different sources, their study shows that I&S holds a significant share in India's export to the EU and that, given the EU's sanctions over Russia, India's position becomes more crucial. Therefore, India and the EU should settle for an international agreement like an FTA for smooth trading between the two countries.

A few papers in the literature show that the imposition of CBAM does not substantially impact global emissions and trade. UNCTAD (2021), using EU domestic carbon prices and border carbon taxes derived from prices approved during the approval of the resolution of the European Parliament on CBAM in 2021 and from pre-simulations done by the EU, shows that CBAM reverses the domestic carbon price effects in EU. While exports of energy-intensive sectors rise in the EU, other countries' exports fall. It shows that CBAM works similarly to tariffs imposed by a trading bloc, thus adversely impacting trade in other regions. It shows that the EU benefits from the terms-of-trade effect and compensates for the loss of resources by shifting to lesser productive activities. It also shows that countries exempt from CBAM coverage benefit due to the effects of income, although global income after the introduction of CBAM has declined. Other findings of the study are: (i) India, South Africa, and other developing countries are among the regions adversely impacted by CBAM, with a few developed countries adversely impacted with lesser intensity, and (ii) I&S exports of developing economies fall by 1.68% to 2.95%, and that of developed countries rise by 0.71% to 1.37%. However, using the GTAP model, the paper shows that carbon leakages can be prevented with the implementation of CBAM. Majumder et al. (2024), using the GTAP 11 database, find that the imposition of CBAM is likely to affect India's cement exports the most. However, overall cement exports to the EU are minimal. In contrast, while I&S exports to the EU form a larger share, the CBAM impact on these is negligible.

Aguiar et al. (2022), employing a general equilibrium model, show that the imposition of carbon tariffs by the EU lowers exports of I&S from India and Ukraine and reduces exports of chemicals from China to the EU. It shows that lower and upper-middle-income economies lose around 8 USD billion and 23 USD billion in exports. Using GTAP-E database 11, Aguiar et al. (2022) show that implementing the EU CBAM proposal will not substantially impact global emission levels, trade, and welfare. This result aligns with previous studies like those of Zhong and Pei (2022) and UNCTAD (2021). It concludes that a broader commodity and emissions coverage (including scope 3 emissions in the EU CBAM proposal) could induce a substantial impact, thereby paving the way toward environmentally sustainable trade policies worldwide.

Using the multi-regional IO model and GTAP database, Zhong and Pei (2022) show that in the short run, the EU output after the imposition of CBAM would increase by 0.38% and that of the world would decrease by 0.1%, with China, India, and Russia bearing the maximum burden. Magacho et al. (2024), using trade data and MRIO matrices, emphasize the geographical and sectoral nature of CBAM's effects. They stated that in relative terms, the degree of exposure of economies varies, with many developing countries, over 2% of exports and 1% of domestic output impacted. In contrast, Chen (2023), using a CGE model, finds that carbon tariffs have a limited effect on China's overall GDP and emissions. Zhao et al. (2024) estimate that China, as a major steel exporter to the EU, could see a 32% decline in export volume and a 58% drop in steel export profits due to CBAM. Similarly, Shuai et al. (2024), under carbon price scenarios of \$60–\$90 per ton, estimate steel trade balance losses between \$317 million and \$424 million in 2027 and 2030. Ghosh and Verma (2025) assess the macroeconomic and fiscal implications of the EU's CBAM for India, focusing on GDP, sectoral competitiveness, exports, fiscal revenue, and welfare. Using three policy scenarios, a domestic carbon tax (PCARBON), a CBAM-driven tax on exports (CBAM), and a hybrid model (PCARBON + CBAM), their results show a small GDP decline of 0.02-0.03% under CBAM due to revenue transfers to the EU. The hybrid scenario mitigates these losses, yielding a marginal 0.01% GDP increase in later years. The iron and steel sector exports to the EU change by 0.72%, - 0.29% and 0.40%, under PCARBON, CBAM, and the hybrid scenario, respectively.

Xiaobei et al. (2022) (Task Force on Climate, Development and the IMF) used a dynamic CGE model to examine the impact of the CBAM on developing countries, finding that it widens the gap between developed and developing nations as income and welfare disparities worsen. The authors further suggest establishing an Equitable Decarbonization Fund, financed by CBAM proceeds, to support decarbonization and green projects in low-income countries. The imposition of carbon tariffs, on the one hand, can hurt both the economic efficiency and distributional aspects of the economy (Ghosh et al., 2012); on the other hand, it can have a positive impact by reducing carbon emissions in the tariff imposing and imposed countries (Chen & Guo, 2017). However, imposing carbon tariffs could also lead to increased carbon leakages, further aggravating carbon emissions (Zhou et al., 2013).

A few papers in the literature summarize the impact of CBAM from all sectors and show a positive impact on trade and emissions. Chen and Guo (2017), using the GTAP model, analyze the impact of carbon tariffs imposed by the EU, Japan, and the USA individually or simultaneously on China's trade competitiveness. It shows that the imposition of carbon tariffs reduces industrial emissions from the heavy manufacturing industries in China and that the exports from light manufacturing industries would increase. The paper using simulation techniques shows that carbon tariffs positively impact domestic emission reductions, thereby increasing exports of low-carbon products. However, the impact on imports of carbon products is relatively greater for the low-carbon industries than the high-carbon ones due to substitution effects between domestic consumption and imports. It shows that carbon tariffs decrease the output of heavy industries and increase the output of light industries.

Using a computable general equilibrium model, Dissou and Eyland (2011) show that border tax adjustments by Canada have a significant positive impact on Canadian industrial competitiveness. According to Gupta et al. (2024), CBAM will likely impact the profitability and trade competitiveness of the exporters and favour countries with faster decarbonization and robust carbon pricing systems. They recommend aligning India's emissions trading system with CBAM impacts, international standards, and global practices to bolster its carbon market and climate goals. Keena and Kotsogiannis (2014), considering climate policy as a global trade instrument, show that a border adjustment tax could lead to optimal Pareto efficiency.

Springmanna (2013), using simulation techniques, studied the impact of carbon tariffs and found that it could facilitate financing for clean energy technology development, thereby reducing carbon emissions for developing countries. Using a marginal cost curve and global energy economy evaluation model, Springmanna (2013) evaluated the impact of carbon tariffs, suggesting they could generate revenues worth \$3.5–24.5 billion that could be utilized for clean energy development and reduce carbon emissions for developing countries by 5–15%. However, it has adverse effects on the GDP of developing countries.

Antimiani et al. (2013) examine the efficacy of alternative trade policy measures. Using two scenarios with and without emission trading, the paper assesses the extent of carbon leakage. It compares a cooperative scenario concerning global emission trading and a non-cooperative scenario where different carbon tariff structures are introduced to deal with carbon leakage. The paper considers the cooperative scenario as the baseline scenario and shows that the carbon leakage effect is more prominent in the non-cooperative scenario. Therefore, the carbon tariffs determined endogenously from the ETS market will provide an upper bound of prices required for reducing carbon leakage or sustaining competitiveness. It concludes that an ETS is the optimal solution to prevent carbon leakage.

Employing a partial equilibrium model, Mathiesen and Maestad (2004) analyze the impact of carbon tariffs on the steel industry. It shows that imposing carbon tariffs would lower the carbon emission level for the global steel industry. Modelling a computable framework based on shared responsibility between both producers and consumers for carbon dioxide emissions, Chang (2013) shows that the carbon tariff rate could serve as a basis for calculating 'shared responsibility' between the supply side and demand side stakeholders, which will decrease China's CO_2 emission. Dong and Whalley (2009), using the GTAP 6.0 database, framed a global computable general equilibrium model and showed that although carbon tariff could reduce carbon leakage, the impact on trade and global emissions is unclear.

Nijkamp et al., (2005), using the GTAP-E model, analyse the impact of international climate change policy instruments like the trading of greenhouse gas (GHG) emission permits (International Emission Trading mechanisms), the GHG emission abatement strategies like achieving emission reduction credits, emission reduction units that are labelled (Joint Implementation mechanisms) and investing in certified emission reduction units (Clean Development mechanisms) on carbon emissions and its pricing strategies. Their objective is not to see the impact on trade competitiveness and GDP. In this paper, they explain how to model different international policy instruments in the GTAP-E framework and the limitations of the implications/interpretations of the model.

Given the ambiguous nature of the literature reviewed above, the present study adds to this literature by evaluating the impacts of the EU's CBAM on India's steel trade, basing the analysis on the recent carbon prices in the EU provided in the EU ETS. The paper also analyzes the impact of CBAM on emissions in India and the EU, and the impact on the major steel-producing countries. The study contributes to existing research by estimating trade elasticities rather than relying on GTAP-based values, which are point elasticities and may overestimate the impact of tariffs such as the CBAM (as discussed in Appendix 2). Integrating these econometrically derived elasticities into the CGE framework helps account for direct and indirect effects, including sectoral linkages, and offers a more comprehensive perspective on the potential implications of carbon tariffs.

6. Methodology of the Present Study and Empirical Results

As discussed earlier, this study aims to understand the impact of the EU's imposition of CBAM on India's steel exports. This study section discusses the approach to the modelling exercise and the results obtained. In Section 7.1, the GTAP model-based general equilibrium analysis to understand the impact of CBAM on India's steel exports and other products, including those covered under CBAM, considers the spillover impacts on other countries' trade patterns and global sectoral shifts. For the analysis in Section 7.1, the EU's applicable carbon price is \$86 per ton of CO_2. This is the price of carbon that prevailed in the EU in 2022 (see Table 2 below).

6.1 ICRIER's *'Samriddhi'* Trade Computable General Equilibrium (CGE) Model

The economic, sector-specific, and spill-over impacts of policy actions are analysed using the Computable General Equilibrium (CGE) models. ICRIER's ***'Samriddhi'*** Trade CGE Model is based on the multi-regional and multi-sectoral GTAP 11 database released in May 2023. The base year of information in the database pertains to 2017. The latest GTAP database, GTAP 11, provides information on bilateral trade flows, emissions, and other economic issues for 65 sectors, 141 countries, and 19 aggregate regions. Regarding regional coverage, the database covers 99% of the world's GDP and 96.4% of the world's population. The database is amenable to further aggregation of the economic sectors and regions.

The ICRIER's ***Samriddhi*** model uses GTAP-E, an extension of the standard GTAP model, and allows for a better representation of the energy-economy linkages than the standard GTAP model. The standard GTAP model does not allow for energy substitution, but GTAP-E allows energy substitution by incorporating energy as a direct input into the production structure. The ICRIER's ***Samriddhi*** model builds upon the model Version 6.2 of the GTAP-E[12].

12 For this study, adjustment has been made to the elasticity of substitution between domestic and imported goods (ESUBD) and the region-specific elasticity of substitution among imports (ESUBM). The adjustment has been made to 3 sectors (Metal Products, Iron and Steel and Metals n.e.c) for the select developed country markets (Australia, EU, Japan, The United States of America and the United Kingdom). Further, details on estimation are available in the appendix 2 of the paper.

6.1.1 Modelling Carbon Tariff in the ‘Samriddhi’ CGE Model

To incorporate the carbon tariffs levied upon importing goods from foreign countries, the study considers for each country the domestic production of the CBAM products, the CO_2 emissions, the share of exports in production, and the carbon price (taken as $86 per ton of CO_2). The additional tax burden has been calculated for different countries, taking into account their CO_2 emission intensity and other relevant factors. Carbon taxation variables are defined within the GTAP-E model. However, no carbon tariff variable is explicitly defined in the GTAP-E model. Therefore, this has been imposed on the model after computing the additional tax burden in supplying to the EU market. The value of CES elasticity between domestic and imported goods (ESUBD) and CES elasticity of import demand across sources (ESUBM) have been estimated. The detailed methodology of estimation is discussed in the appendix 2 of the paper.

6.2 Modelling CBAM

The first step in CGE modelling is determining the regions and sectors included in the model. In this case, a trade analysis is undertaken to determine the key sectors and partners of India and the EU. As a result, this study aggregates the data for 26 sectors and 29 regions (See appendix 3).

6.2.1 Identifying CBAM Sectors

The objective of this study is to simulate the CBAM scenario in a way that is as realistic as possible to the actual notification by the European Parliament. The Regulation (EU) 2023/956 of the European Parliament and of the Council of 10th May 2023 establishes the CBAM. The regulation in Annex I lists the set of goods and greenhouse gases subject to CBAM. In the initial phase, the CBAM targets specific goods and their precursors with high carbon intensity, representing the most pronounced risk of carbon leakage when imported. These goods are cement, I&S, aluminium, fertilizers, electricity, and hydrogen. Annex 1 of the EU CBAM regulation lists the relevant HS Codes; these HS codes are mapped to identify the relevant GTAP sectors that shall be subjected to CBAM. The concordance between HS codes and the GTAP sectors is provided by Aguiar (2016). Table 1 provides the mapping between GTAP sectors and the CBAM commodities:

Table 1: Mapping CBAM commodities and GTAP sectors

CBAM Commodity	GTAP Sector	GTAP Sector Description
Cement	Oxt	Other Mining Extraction (formerly omn): mining of metal ores; other mining and quarrying
	Nmm	Manufacture of other non-metallic mineral products
I&S	Fmp	Manufacture of fabricated metal products, except machinery and equipment
	Oxt	Other Mining Extraction (formerly omn): mining of metal ores; other mining and quarrying
	i_s	Iron & Steel: basic production and casting
Aluminium	Fmp	Manufacture of fabricated metal products, except machinery and equipment
	Nfm	Non-Ferrous Metals: production and casting of copper, aluminium, zinc, lead, gold, and silver
Fertilizers	Chm	Manufacture of chemicals and chemical products
Electricity	Ely	Electricity; steam and air conditioning supply
Hydrogen	Chm	Manufacture of chemicals and chemical products

Source: Authors’ Compilation

6.2.2 Identifying CBAM Regions

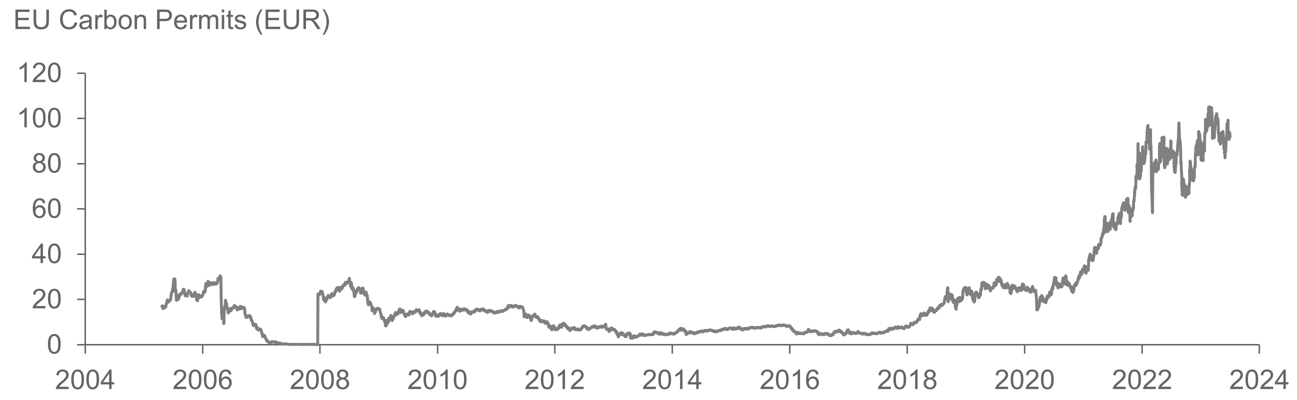
Annex 3 of the EU regulation lists the countries outside the scope of this regulation. It includes four European countries: Iceland, Liechtenstein, Norway, and Switzerland. In addition, article 9 of the CBAM regulation allows for a reduction in the carbon price paid in the third country, i.e., if the commodity has been subject to a domestic carbon tax in the source country of production, then the importers can claim a deduction.

Using the information on domestic carbon taxes from the Carbon Pricing Dashboard of the World Bank, the set of countries with existing carbon taxes are identified. In determining the tax rate applicable under CBAM, an appropriate adjustment is made for the countries identified.

6.2.3 Calculating the CBAM Levy

As per the official CBAM regulation, the Commission will determine the price of CBAM certificates by taking the weekly average of the closing prices of EU ETS allowances on the auction platform for each calendar week—Figure 10 below shows the closing prices of the EU ETS allowances daily. **Since the GTAP database corresponds to a particular year (2017), yearly averages are calculated using the closing prices of the EU ETS allowances**—Table 2 shows the annual average prices from 2017 onwards. The analysis in the present section has been done by using a carbon price of $86.1 per ton of CO_2, which was the price prevailing in 2022. This is much higher than the price in 2020 or 2021. However, it appears that it would be appropriate to undertake the analysis at a higher carbon price since the prevailing price has been on higher side.

Figure 10: EU Carbon Permits (EUR)



Data Source: Trading economics

Table 2: Yearly average EU Carbon Permit Price (USD)

Year	Yearly average EU Carbon permit price (USD)
2017	6.64
2018	18.69
2019	27.84
2020	28.40
2021	62.79
2022	86.01
2023	101.14

Source: Authors' computation

7. The Results

7.1 Impact on GDP and Trade

The global GDP is likely to witness a marginal increase of 0.01% due to the imposition of the CBAM by the EU. The small increase in global GDP reflects the price and composition effects rather than an improvement in productive efficiency. The EU's CBAM creates marginal gains and losses of GDP for countries across the world. Among the countries witnessing the decline are Ukraine (-0.45%), Russia (-0.17%), Saudi Arabia (-0.10%), and Singapore (-0.09%). For India, the GDP will decline by 0.04%. The EU, the UK, and CBAM-Exempt countries, including Switzerland, Norway, and other EFTA countries, benefit from the CBAM. The distributional consequences are asymmetric: the EU records a welfare gain driven by a large positive terms-of-trade effect, despite a decline in allocative efficiency, while most other regions experience welfare losses. Thus, the results highlight the standard trade theory: the CBAM reduces global efficiency and real output but redistributes gains toward the EU through favourable terms-of-trade effects.

The imposition of CBAM by the EU shall reduce its global import of fertilizers, cement, aluminium, and I&S (see Table 3). However, excluding the intra-EU trade, i.e., trade among the partners within the EU, shows a higher decline in imports by the EU. This implies that imports of fertilizers, cement, aluminium, and I&S from within the EU will partly replace imports from the non-EU countries.

Table 3: CBAM Impact on trade: EU imports from the World and India

CBAM Sectors	Model Sectors	CBAM@ $86.01	
EU's Imports from the World (% Change)			
		Excluding Intra-EU trade	Including Intra-EU Trade
Cement, Iron and Steel	Other Extraction (oxt)	0.50%	0.52%
Cement	Mineral products nec (nmm)	-10.53%	-1.04%
Aluminium, Iron and Steel	Metal Products (fmp)	-2.24%	-0.18%
Iron and Steel	Iron and Steel (i_s)	-9.01%	-0.07%
Aluminium	Metals nec (nfm)	-1.07%	-0.07%
Fertilizers	Chemical Products (chm)	-9.58%	-0.03%
EU's Imports from India (% Change)			
Cement, Iron and Steel	Other Extraction (oxt)	0.71%	-
Cement	Mineral products nec (nmm)	-1.92%	-
Aluminium, Iron and Steel	Metal Products (fmp)	-4.30%	-
Iron and Steel	Iron and Steel (i_s)	-23.94%	-
Aluminium	Metals nec (nfm)	-10.13%	-
Fertilizers	Chemical Products (chm)	-16.80%	-

Source: Authors' estimates based on scenario analysis
Note: The change in value of imports has been calculated considering the import value at CIF prices.

Imports from India would also decline for all CBAM commodities. The impact of the CBAM is likely to be felt the most by the I&S sector, where the extent of the decline in imports by the EU could be about -24%. Because most CBAM exports from India to the EU are from the I&S sector and within the sector, the end use of the product being intermediate use, the result perfectly aligns with the economic intuition, i.e., the impact is felt where the trade is higher. The fertilizers and aluminium products, followed by metal products, are next in line to be hurt the most.

India's global export of I&S will decline by 5.7%; for China, the corresponding estimate is 1.2%. This reduction is primarily due to a reduction in exports to the EU. The table below shows the percentage change in India's and China's I&S exports to different markets. There is a marginal increase in I&S exports to different export markets, particularly to the CBAM-exempt countries, including Switzerland, Norway, and the Rest of the European Free Trade Association (EFTA).

Table 4: CBAM Impact on China and India's Export of I&S in Different Markets (% Changes)

Export Destination	China	India	Export Destination	China	India
Argentina	0.36%	0.50%	**UK**	0.60%	0.61%
Australia	0.12%	0.13%	**USA**	0.17%	0.18%
Brazil	0.53%	0.67%	**CBAM Exempt**	3.01%	3.16%
Canada	0.35%	0.49%	**Singapore**	0.40%	0.54%
EU27	-22.45%	-23.94%	**Ukraine**	-1.02%	-0.88%
Africa Union	0.49%	0.63%	**Chile**	0.32%	0.46%
Indonesia	0.10%	0.25%	**Colombia**	0.19%	0.33%
Japan	0.10%	0.11%	**East Asia**	0.14%	0.28%
Korea	0.23%	0.37%	**South-East Asia**	0.17%	0.31%
Mexico	0.36%	0.50%	**South Asia**	0.17%	0.31%
Russia	-0.29%	-0.14%	**Latin America**	0.25%	0.39%
Saudi Arabia	0.06%	0.20%	**Middle East**	0.16%	0.30%
South Africa	0.59%	0.73%	**Rest of World**	-0.05%	0.09%
Turkey	0.92%	1.07%			

Source: Authors' estimates based on scenario analysis
Note: The change in value of exports has been calculated considering the export values at FOB prices.

The results indicate that the imposition of CBAM will cause a significant fall in India's and China's exports of I&S products to the EU market. However, there will be no significant change in India's and China's exports to other countries.

Attention may be drawn here to a study undertaken by Xiaobei et al. (2022) (Task Force on Climate, Development and the IMF) on the impact of CBAM. They used a model built on the dynamic CGE models by Van der Mensbrugghe (2019) and Zhai (2018) and calibrated to the GTAP 10 database. According to their estimates, CBAM will lead to a 60% fall in India's ferrous metal exports.[13] Their estimated fall in India's exports is about 10 to 12% for non-ferrous metals and chemicals. Compared to the estimate by Xiaobei et al. (2022), our estimate of a fall in India's iron and steel exports to the EU market is substantially lower. While they estimate a 60% fall in India's exports of iron and steel products to the EU market, we estimate it at about 24%.

For non-ferrous metals, Xiaobei et al. (2022) estimate the fall in India's exports to the EU to be about 10%. The estimate obtained in this study matches the estimate of Xiaobei et al. (2022). At the same time, it is important to take sufficient caution in interpreting the estimates obtained from a CGE model. In the context of their study aimed at assessing the impact of border tax adjustment (BTA), Goldar and Bhalla (2012) draw attention to certain limitations of such models: (1) The models rarely incorporate the carbon tax-induced technological advance though there are exceptions, (2) The GTAP data based CGE models use the same set of elasticities of substitution for all countries, which may not be right mainly if the elasticities for developed countries are applied to developing countries, and (3) There is often an assumption of inelastic labour supply and full employment. Hence, a carbon tax that lowers energy demand in the economy and shrinkage of the energy-producing sectors does not lead to unemployment. Instead, the workers shift to other industries, and the market wage is driven down, lowering the cost of production in energy-using industries, which partially nullifies the impact of a carbon tax.

In sum, the results of the GTAP model indicate that CBAM will cause a 24% decrease in India's steel exports to the EU and about a 10% fall in exports of non-ferrous metal (aluminium).

7.2 Impact on Carbon Emissions

Addressing carbon leakage is the primary objective of the CBAM proposed by the EU. It seeks to do so by equalising the price of carbon domestically and externally to ensure that emission increases in other countries do not accompany reductions in EU emissions. The analysis of these estimates (Table 5) indicates that there will be a reduction in carbon emissions in India of 0.26%, mainly because of reduced emissions from the combustion of coal (-0.17%) and oil products (-0.08%). The EU emissions increase is not because EU firms become dirtier, but because the CBAM shock is modelled as an import tax/tariff-equivalent shock on carbon-intensive imports into the EU. The shock is imposed on imports into the EU27 from non-EU regions, while EU-to-EU flows are zero-rated. For example, India faces a large shock in Iron & Steel exports to the EU, while the EU27's own I&S flows are unaffected. This raises the relative price of imported CBAM goods and shifts production toward EU producers. This is visible in the EU sectoral output results, and since Iron & Steel is energy-intensive, higher EU production raises demand for energy inputs.

The carbon emissions are likely increase in the EU by 0.29%. The increase in the emissions of the EU is due to the increased usage of coal (0.11%), gas (0.09%), and oil products (0.08%). The increase in carbon emissions for the EU is of both direct and indirect nature and confirms that the rise is mainly a scale effect from increased domestic EU production, keeping the EU technology mix and efficiency held constant. The increased domestic production in the sectors subject to the CBAM and electricity production leads to increased direct emissions, while the indirect emissions increase through the electricity sector. However, the extent of the increase/decrease is very small in India and the EU.

13 In the study undertaken by Xiaobei, et al. (2022), the tariff equivalence of CBAM for India's steel exports has been taken as about 15%.

Table 5: CBAM Impact on carbon emissions: By fuel

Country	Fuel	Change (%)	Decomposition of Total Change (%)
India	Coal	-0.26%	-0.17%
	Oil	-0.32%	0.00%
	Gas	-0.13%	0.00%
	Oil Products	-0.26%	-0.08%
	Total	**-0.26%**	**-0.26%**
EU	Coal	0.48%	0.11%
	Oil	0.54%	0.00%
	Gas	0.38%	0.09%
	Oil Products	0.16%	0.08%
	Total	**0.29%**	**0.29%**

Source: Authors' estimates based on scenario analysis

Another issue that needs investigation is whether, at the global level, there is a reduction in carbon emissions because of shifts in trade and, hence, shifts of production from countries with relatively high carbon intensity of CBAM products to countries with relatively low carbon intensity of CBAM products. Therefore, the carbon emission associated with steel production in selected countries have been aggregated, and whether there has been a fall in the aggregate emissions has been studied. The results are reported in Table 6. The results indicate a minor decrease in the carbon emission intensity (-0.53%) at the global level. The trend is driven by the EU, where the fall in emission intensity is of a similar magnitude as the global level.

Table 6: Percent change in carbon intensity in the I&S industry in different countries

Change (%)-Emission Intensity (CO_2 per unit of Output Value)			
Argentina	0.01%	**UK**	-0.07%
Australia	0.04%	**USA**	0.02%
Brazil	0.02%	**CBAM Exempt**	-0.05%
Canada	0.01%	**Singapore**	-0.06%
China	0.02%	**Ukraine**	0.19%
EU27	-0.55%	**Chile**	0.13%
India	0.04%	**Colombia**	-0.03%
Indonesia	0.02%	**East Asia**	0.02%
Japan	0.02%	**South East Asia**	0.01%
Korea	0.02%	**South Asia**	-0.05%
Mexico	-0.02%	**Latin America**	0.02%
Russia	0.10%	**Middle East**	0.01%
Saudi Arabia	0.09%	**Rest of World**	0.08%
South Africa	-0.01%	**World**	-0.53%

Source: Authors' estimates based on scenario analysis

The disaggregate analysis of carbon emissions by the fuel products in the major steel-producing countries indicates that the aggregate emission reduces in some countries, while it increases in others. While in India the decline in emissions is led by reduced usage of coal, in Russia and Ukraine it is due to the oil products.

Table 7: Percent change in CO_2 emissions by the I&S industry in major steel-producing countries: By Fuel products

Countries	Decomposition of Change (%)				
	Coal	Oil	Gas	Oil products	Total
Brazil	-0.06%	0.00%	-0.02%	-0.09%	-0.17%
China	-0.01%	0.00%	0.00%	-0.04%	-0.06%
India	-0.89%	0.00%	-0.02%	-0.65%	-1.57%
Japan	0.01%	0.00%	0.01%	0.10%	0.12%
Korea	0.03%	0.00%	0.01%	0.06%	0.11%
Russia	-0.14%	0.00%	-0.47%	-1.62%	-2.23%
Turkey	0.05%	0.00%	0.08%	0.12%	0.25%
USA	0.01%	0.00%	0.06%	0.08%	0.14%
Ukraine	-0.33%	0.00%	-0.32%	-2.21%	-2.86%
Rest of the World	-0.06%	0.00%	-0.09%	-0.38%	-0.52%
All	-0.14%	0.00%	-0.02%	-0.22%	-0.38%

Source: Authors' estimates based on scenario analysis

8 Conclusion

The paper uses the general equilibrium analysis to estimate the impact of CBAM implementation by the EU on India's trade patterns and environmental changes. The study shows that implementing the CBAM by the EU will likely reduce Indian exports in the I&S sector. Under the general equilibrium approach, India's steel exports to the EU shall reduce by 24%. This implies that the carbon tax burden falls on Indian firms, adversely affecting gains from exports to the EU. Even China's exports fall by about 23% with the imposition of CBAM by the EU, according to the obtained results. This also implies that carbon emissions of the intermediate products being exported to the EU from India and China are high, thus reducing imports by the EU.

The 0.01% increase in global GDP reflects the price and composition effects rather than an improvement in productive efficiency and is consistent with the standard trade theory related to real output efficiency and associated welfare gains. Furthermore, the objective with which the CBAM proposal was put forward, i.e., controlling carbon leakage and reducing emissions, may remain largely unaccomplished. The study shows that taxation on fuel use reduces India's carbon emissions from fuel usage, although the impact is very small. This shows that taxing fuel usage is not sufficient, but the ability to shift to non-fossil energy sources becomes crucial. Other recent studies have arrived at similar results. On the contrary, the study shows that the EU's emissions are rising nominally, largely due to the scale effect from increased domestic EU production.

It should be noted that the carbon emissions of the global steel industry fell only marginally after the implementation of CBAM, even though significant reductions took place in the steel exports of India, China, and certain other countries to the EU. This suggests that the production relocation aided by the shift of trade does not yield substantial gains in containing carbon emissions, although there are country-specific gains in India, Russia, and Ukraine.

In conclusion, CBAM shall adversely impact India's trade with the EU and will have a negligible effect on carbon emissions. To circumvent this export loss, India should find avenues to boost the sector's export share while reducing emissions, aligning with its Long-Term Low-Emissions Development Strategy (LT-LEDS) and net-zero 2070 commitment. India should identify partners that help recoup lost export market share by implementing CBAM. It can shift to a higher value-added product export in the I&S sector so that the tax rate on the exports from India would be lower, and thus, the disadvantage caused by CBAM will be less. Industrial policies integrating Production Linked Incentives (PLI) and research support can reinforce the structural shift towards decarbonisation. The impact level on carbon emissions is hard to determine and depends on the type of inputs used to produce the finished goods in the sector. Technological upgrades and energy efficiency improvements can provide negative cost abatement and low-cost opportunities (ETC, 2018). Targeted financial and technical support, such as concessional funding, access to clean technologies, and investment guarantees, can help MSMEs that face disproportionate compliance burdens.

To prevent carbon emissions at the production stage so that India's exports to the EU do not get taxed under CBAM, India could either charge a domestic carbon tax or leverage its Carbon Credit Trading Scheme (CCTS), which allows carbon credits to be traded with other countries. Another policy recommendation could be to press for lowering the carbon tax rate charged by the EU to developing economies like India in various international fora. A comprehensive and robust domestic carbon market that enables credit generation and international linkage under Article 6 of the Paris Agreement would help retain revenues within the country and support a just transition. Porter's Hypothesis suggests that well-designed market-based environmental regulation can spur innovation, improving long-run competitiveness (Porter & van der Linde, 1995).

However, the practical implementation of the suggested policies must account for the unique challenges faced by industries in India for decarbonization. The I&S sector, similar to other carbon-intensive industries, faces high capital costs, limited availability of low-carbon technologies, and infrastructure constraints for renewable energy integration. Gaps in energy-intensive production processes and workforce skill requirements further create constraints on decarbonization. Therefore, policies such as PLI-linked decarbonization incentives come into play, with targeted research and development support, and technology transfer partnerships should be prioritized to address these barriers.

Lastly, strengthening Monitoring, Reporting, and Verification (MRV) systems is essential to ensure credible emissions accounting and minimize the risk of market exclusion. Adopting standardized measurement protocols, digital traceability systems, and dedicated compliance support for MSMEs will be critical to mitigate supply chain disruptions (Singh et al., 2025).

Addressing CBAM-related trade exposure requires a targeted decarbonisation strategy for India's I&S sector, one that shifts production toward low-carbon technologies, improve sustainability and circularity, and strengthens value-chain competitiveness to secure long-term access to developed country export markets.

References

Aguiar, A. (2016). Concordances - six-digit HS sectors to GTAP sectors . Purdue University, West Lafayette, IN: Global Trade Analysis Project (GTAP). Retrieved from https://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=5111

Aguiar, A., Chepeliev, M., Corong, E., and Mensbrugghe, D. V. D. (2022). The Global Trade Analysis Project (GTAP) Data Base: Version 11. Journal of Global Economic Analysis, 7(2), 1-37.

Antimiani, A., Costantini, V., Martini, C., and Salvatici, L. (2013). Assessing alternative solutions to carbon leakage. Energy Economics, 36, 299–311. DOI:10.1016/j.eneco.2012.08.042

Badri, N.G., Walmsley, T.L. (2008). Global Trade, Assistance, and Production: The GTAP 7 Data Base; Purdue University: Purdue, IN, USA.

Bajzik, J., Havranek, T., Irsova, Z., & Schwarz, J. (2019). The elasticity of substitution between domestic and foreign goods: A quantitative survey; ZBW – Leibniz Information Centre for Economics, Kiel, Hamburg

Business Standard (2023). China hits Australian industries with economic sanctions amid souring ties. August 7. Retrieved from: https://www.business-standard.com/article/international/china-hits-australian-industries-with-economic-sanctions-amid-souring-ties-121070900082_1.html

Chadha, R., Pohit, S., and Pratap, D. (2021). The US–China Trade War: Impact on India and Other Asian Regions. Sage Journals, 3(2). Retrieved from: https://journals.sagepub.com/doi/10.1177/26316846211038223

Chang, N. (2013). Sharing responsibility for carbon dioxide emissions: A perspective on border tax adjustments. Energy Policy, 59, 850–856.

Chen, G. (2023). Impact of carbon border adjustment mechanism on China's manufacturing sector: a dynamic recursive CGE model based on an evolutionary game. Journal of Environmental Management, 347, 119029.

Chen, W., and Guo, Q. (2017). Assessing the Effect of Carbon Tariffs on International Trade and Emission reduction of China's Industrial Products under the Background of Global Climate Governance. Sustainability, 9, 1028.

Council of the EU (2022). CBAM: Commission Proposal. Interinstitutional File: 2021/0214(COD), October 3, 2022, Brussels.

De Miguel, C., Ludena, C., and Schuschny, A. (2009). Climate Change and Reduction of CO_2 Emissions: the role of Developing Countries in Carbon Trade Markets. Paper prepared for presentation at the Twelfth Annual Conference on Global Economic Analysis, Santiago, Chile, June 10-12.

Dissou, Y., and Eyland, T. (2011). Carbon control policies, competitiveness, and border tax adjustments. Energy Econ., 33, 556–564.

Dong, Y., and Whalley, J. (2009). How Large Are the Impacts of Carbon Motivated Border Tax Adjustments; Working Paper 15613. National Bureau of Economic Research (NBER): Cambridge, MA, USA, 2009.

ETC. (2018). Mission Possible: Reaching net-zero carbon emissions from harder-to-abate sectors by mid-century. Energy Transitions Commission. Retrieved from https://www.energy-transitions.org/wp-content/uploads/2020/08/ETC_MissionPossible_FullReport.pdf

EUROMETAL (2023). EU extends sanctions on imports of products, goods containing Russian steel. EUROMETAL, 28th June 2023. Retrieved from: https://eurometal.net/eu-extends-sanctions-on-imports-of-products-goods-containing-russian-steel/

European Commission (2023a). EU adopts 11th package of sanctions against Russia for its continued illegal war against Ukraine. Retrieved from: https://ec.europa.eu/commission/presscorner/detail/en/ip_23_3429

European Commission (2023b). Sanctions adopted following Russia's military aggression against Ukraine. Retrieved from: https://finance.ec.europa.eu/eu-and-world/sanctions-restrictive-measures/sanctions-adopted-following-russias-military-aggression-against-ukraine_en

Fajgelbaum, P.D., Goldberg, P. K., Kennedy, P. J., and Khandelwal, A.K. (2019). The Return to Protectionism. WORKING PAPER 25638, NBER. Retrieved from: https://www.nber.org/papers/w25638

Freund,C., Ferrantino,M. J., Maliszewska,M., and Ruta,M. (2018). Impacts on Global Trade and Income of Current Trade Disputes (English). MTI Practice Note,no. 2 Washington, D.C. : World Bank Group. Retrieved from: http://documents.worldbank.org/curated/en/685941532023153019/Impacts-on-Global-Trade-and-Income-of-Current-Trade-Disputes

Gallaway, M. P., McDaniel, C. A., & Rivera, S. A. (2003). Short-run and long-run industry-level estimates of US Armington elasticities. The North American Journal of Economics and Finance, 14(1), 49-68.

Ghosh, J., and Verma, R. (2025). Assessing the Distributional Implications of the EU's CBAM on India: A CGE Analysis (CSEP Working Paper 100). New Delhi: Centre for Social and Economic Progress.

Ghosh, M., Luo, D.M., Siddiqui, M.S., Zhu, Y. (2012). Border tax adjustments in the climate policy context: CO_2 versus broad-based GHG emission targeting. Energy Economics, 34, S154–S167.

Goldar, B and Bhalla, M. (2012). Assessing the Likely Impact of Carbon Taxes on India's Exports, Domestic Production and Employment. Report, May, Centre for WTO Studies, Indian Institute of Foreign Trade, New Delhi.

Goldar, B and Goldar, A. (2022). 'Impact of export intensity on energy intensity in manufacturing plants: Evidence from India.' Journal of International Trade and Economic Development, https://doi.org/10.1080/09638199.2022.2125552 .

Goldar, B., and Pratap, D. (2013). Emission Reduction Commitments and International Carbon Trading: Assessment of Impact on India and China Based on GTAP-E Model (January 27, 2013). Available at SSRN: https://ssrn.com/abstract=2207651 or http://dx.doi.org/10.2139/ssrn.2207651

Goldar, A., Ali, MD S., Kotal, M., Bhattacharya, P., and Haque, I. (2023). Policy Landscape for Transition Towards Carbon Neutral Steel Sector. Forthcoming, ICRIER POLICY BRIEF.

Gupta, A., Pandey, R., & Sapatnekar, S. (2024). Potential implications of the EU's Carbon Border Adjustment Mechanism. Working Paper No. 408, March 2024, National Institute of Public Finance and Policy.

Hasanbeigi, A., Lu, H., and Zhou, N. (2023). Net-Zero Roadmap for Chinese Steel Industry. Lawrence Berkeley National Laboratory, and Global Efficiency Intelligence. LBNL-2001506 https://eta-publications.lbl.gov/sites/default/files/china_steel_roadmap-2mar2023.pdf.

IEA (2020). Iron and Steel Technology Roadmap: Towards more sustainable steelmaking. Part of Energy Technology Perspectives, October 2020.

Imbs, J., & Mejean, I. (2010). Trade elasticities: a final report for the European Commission (No. 432). Directorate General Economic and Financial Affairs (DG ECFIN), European Commission.

India Brand Equity Foundation (IBEF) (2023). Steel Industry Report. Available at https://www.ibef.org/industry/steel

IPCC (2023). Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland, 184 doi:10.59327/IPCC/AR6-9789291691647.

Keena, M., and Kotsogiannis, C. (2014). Coordinating climate and trade policies: Pareto efficiency and the role of border tax adjustments. J. Int. Econ., 94, 119–128.

Kneppelhout (2023). EU sanctions measures against Russia (update). Retrieved from: https://kneppelhout.com/news/eu-sanctions-measures-against-russia/

Kowalski, P., and Legendre, C. (2023). Raw materials critical for the green transition: Production, international trade and export restrictions.

Kuik, O., and Hofkes, M. (2010). Border adjustment for European emissions trading: Competitiveness and carbon leakage. Energy Policy, 38, 1741–1748.

Magacho, G., Espagne, E., & Godin, A. (2024). Impacts of the CBAM on EU trade partners: consequences for developing countries. Climate Policy, 24(2), 243-259.

Majumder, P., Mathur, S., & Pohit, S. (2024). Impact of the European Union's Carbon Border Adjustment Mechanism-Evidence from India and Other Selected Trading Partners of EU. Green and Low-Carbon Economy. doi: 10.47852/bonviewGLCE42022065

Mathiesen, L., and Maestad, O. (2004). Climate Policy and the Steel Industry: Achieving Global Emission Reductions by an Incomplete Climate Agreement. Energy J., 25, 91–114.

Németh, N., Szabó, L. and Ciscar, J-C (2011). Estimation of Armington elasticities in a CGE economy–energy–environment model for Europe, Economic Modelling, 28(4), 1993-1999,

Nijkamp, P., Wang, S., and Kremers, H. (2005). Modeling the impacts of international climate change policies in a CGE context: The use of the GTAP-E model. Economic Modelling 22(6):955-974. DOI:10.1016/j.econmod.2005.06.001

Porter, M., and C. van der Linde (1995). Toward a New Conception of the Environment Competitiveness Relationship. Journal of Economic Perspective 9(4). 97

Reuters (2022). Australia's prime minister says China should lift trade sanctions; welcomes talks. Reuters. Retrieved from: https://www.reuters.com/world/asia-pacific/australia-pm-says-china-should-lift-trade-sanctions-welcomes-talks-2022-06-14/

Sharma, V., and Gupta, K. (2023). Implications of Carbon Border Adjustment Mechanism: A case of India's exports to EU. Journal of Resources, Energy, and Development, 18 (1&2), 55–76.

Shuai, J., Wang, W., Liu, H., Huang, C., Yi, T., Zhao, Y., & Shuai, C. (2024). The impact of the EU's Carbon Border Adjustment Mechanism on the global iron and steel trade and emission reduction. Environmental Science and Pollution Research, 31(14), 21524-21544.

Singh, H., Sharma, A., & Chaturvedi, V. (2025). EU Carbon Border Adjustment Mechanism: Dominant Perspectives in India. New Delhi. Council on Energy, Environment and Water.

Springmanna, M. Carbon tariffs for financing clean development (2013). Climate Policy, 13, 20–42.

The Guardian (2021). Australia proves resilient against China trade sanctions but loses diplomatic influence in Asia. December 2021. Retrieved from: https://www.theguardian.com/australia-news/2021/dec/05/asia-power-index-australia-weathers-china-trade-sanctions-but-diplomatic-influence-wanes

Truong, T. P. (1999). GTAP-E: Incorporating Energy Substitution into the GTAP Model. GTAP Technical Paper No. 16, December.

UNCTAD. (2021). A EU Carbon Border Adjustment Mechanism: Implications for developing countries. UNCTAD. Retrieved from: https://unctad.org/system/files/official-document/osginf2021d2en.pdf.

Van der Mensbrugghe, D. (2019). The Environmental Impact and Sustainability Applied General Equilibrium (ENVISAGE) Model.

World Steel Association (2021). Climate change and the production of iron and steel. Public Policy paper, World Steel Association. Retrieved from: https://worldsteel.org/publications/policy-papers/climate-change-policy paper/#:~:text=In%202020%2C%20on%20average%2C%20every,between%207%25%20and%209%25

WTO (2022). Decarbonization Standards and the Iron and Steel Sector: How can the WTO Support Greater Coherence? Trade and Climate Change. Information Brief No 7, 12th December 2022. Retrieved from: https://www.wto.org/english/tratop_e/envir_e/trade-climate-change_info_brief_no7_e.pdf

Xiaobei, H., Fan, Zhai, and Jun, M. (2022). The Global Impact of a Carbon Border Adjustment Mechanism: A quantitative assessment, The Task Force on Climate, Development and the IMF.

Welsch, H. (2008). Armington elasticities for energy policy modeling: Evidence from four European countries, Energy Economics,30 (5), 2252-2264.

Yano, T., Kojima, S., and Zhou, X. (2011). The Economic and Environmental Effects of Border Adjustment Measures: A multi-regional CGE analysis for Japan. Institute for Global Environmental Strategies, Kanagawan, Japan; presented at the 19th International Input-Output Conference, Alexandria, Virginia, USA, 13-17 June, 2011.

Zhai, Fan (2018). China's belt and road initiative: A preliminary quantitative assessment. Journal of Asian Economics, 55 : 84–92.

Zhao, L. T., Chen, Z. Y., Duan, Y. X., & Qiu, R. X. (2024). How will CBAM affect the decarbonisation of steel industry in China? A system dynamics approach. International Journal of Production Research, 62(18), 6859-6880.

Zhong, J., and 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. Retrieved from: https://www.sciencedirect.com/science/article/pii/S0301421522000271

Zhou, X., Yano, T., and Kojirna, S. (2013). Proposal for a national inventory adjustment for trade in the presence of border carbon adjustment: Assessing carbon tax policy in Japan. Energy Policy, 63, 1098–1110.

Appendix

Appendix 1: Note on GTAP-E Model

The Computable General Equilibrium (CGE) model was employed with an endogenous income distribution mechanism for the Indian economy, built as a multi-sectoral general equilibrium model. It represents a competitive market economy in which the producers maximize profit, and consumers maximize their utilities subject to a budget constraint while maintaining standard economic and behavioral assumptions. The calibration process includes specifying the model's parametric values to be consistent with the base-year data. After the benchmark calibration, the model generated equilibrium values of important macro variables. The results generated were analyzed to devise optimum policy recommendations for the country.

To gauge the trade competitiveness in lieu of emissions taxation, the Global Trade Analysis Project (GTAP) database was employed, which assisted in formulating a multi-regional and multi-sectoral CGE model and is comprehensive in the quantitative simulation of the data (Badri and Walmsley, 2008). More specifically, we employ the GTAP-E database, the Energy-Environmental Version of the GTAP Model. It incorporates the emission accounting systems for products used in production and consumption (Truong, 1999). GTAP-E is a module based on the GTAP 11 (version pre 6.2) database and extended energy balances compiled by the International Energy Agency (IEA). It provides CO_2 emissions data released from the burning of fossil fuels by users from all the countries/regions in the GTAP database and considers energy substitution. We use the GTAP-E database and GEMPACK software for simulations and solving the model.

Two important reasons for using the GTAP-E CGE model are the distinctive production and consumption structures that constitute the substitution parameters (de Miguel, Ludena, and Schuschny, 2009). On the production side, it combines energy inputs with capital to produce an energy-capital composite in the value-added nested function. Then, a Constant Elasticity of Substitution (CES) function is combined with primary inputs. Energy factors are further segregated with different levels of elasticity of substitution. First, it is segregated into electric and non-electric commodity groups. The nesting further segregates non-electric commodity groups into coal and non-coal and further non-coal into gas, petroleum, and petroleum products. On the consumption side, the government consumption in the GTAP-E model differs from that in the standard GTAP model because the demand for composite is further segregated into the energy (electricity, coal, gas, petroleum, and petroleum products) and non-energy composite with different substitution parameters. The household private consumption, like the standard GTAP model, follows a constant difference of elasticities (CDE) functional form. Nevertheless, in the GTAP-E model, it is again segregated into energy and non-energy composite. The elasticity of substitution parameters is derived from metadata. The literature shows that recent versions of the model assume a lesser energy substitution parameter to depict a realistic picture of the price elasticity of demand (Goldar and Pratap, 2013). GTAP-E CGE model assumes:

- Perfect competition
- Constant returns to scale
- Labor is mobile across production sectors but not regions
- Capital is mobile across the world
- The model has regional households, firms, a global bank and a transportation sector.
- Armington assumptions on substitution between domestic goods and imports

The equation system is mainly composed of:

- accounting equations, and
- behaviours of economic bodies.

Limitations of the GTAP-E model

- The model does not account for other GHG emissions except the CO_2 emissions. GTAP-E model also does not provide information on process-related CO_2 emissions. This analysis is beyond the scope of the present analysis.
- The model does not allow gauging the recycling or redistribution of the carbon tax revenue generated with a gradual introduction of a carbon tax. However, the tax revenues could be accounted for using the CGE model.
- The GTAP-E model cannot model gradual carbon tax implementation and can only assess structural long-term changes.
- Also, the GTAP model does not model short-term fluctuations. It has fixed aggregated demand at the base year and in estimating future trends. Therefore, the short-term effects may be substantially higher than structural changes.

Appendix 2: Estimating the trade elasticities

The GTAP database includes a set of elasticities estimated during data preparation. Two key elasticities are particularly relevant for this study in the production structure. The first is the elasticity of substitution between domestic and imported goods (ESUBD), which plays a critical role in determining the allocation between these goods. At the next level, the region-specific elasticity of substitution among imports (ESUBM) allocates imported goods across different regions in the model. Generally, ESUBD is set at half the value of ESUBM. In the case of I&S, the default values within the GTAP database of ESUBM and ESUBD for EU were -5.9 and -2.95, respectively.

When an analysis of the impact of CBAM on India's export to the EU was done by using the GTAP-E database applying the built-in trade elasticities mentioned above, the results indicated a large fall in India's exports of I&S products to the EU, similar to the results reported by Xiaobei et al. (2022). An investigation into the reasons for the estimated large impact on India's I&S exports to the EU revealed that this was primarily caused by the relatively large trade elasticities, ESBUD and ESUBM, in GTAP database.

The trade elasticities in the GTAP database may be treated as point elasticities. When there is a small change in tariff or other similar changes, the model provides a useful indication of the direction and magnitude of change in production, trade, prices, etc, that is likely to take place. However, in case the change in tariff to be considered for the analysis is a large one, as in the case of CBAM, the resultant change may get over-estimated if the assessment is based on point elasticities. This is one consideration why a downward adjustment in trade elasticities in GTAP database may be needed when studying the impact of CBAM.

Another point that should be noted in this context is that some of the available estimates of trade elasticities in the literature are much lower in absolute value than the trade elasticities specified in the GTAP database.

In the GTAP database, ESUBD for manufactured products ranges from 2.1 to 4.4, and the simple average across sectors is 3.5. By contrast, Bajzik et al. (2019) who have carried out a meta-analysis of the Armington elasticity (the elasticity of substitution between domestic and foreign goods) estimates made in various studies find that, for manufacturing, the mean of the elasticity estimates is 1.4, which is well below the trade elasticity used in the GTAP database. The elasticity is lower for developed countries than for developing countries. The implication is that if one is considering the elasticity of substitution between domestic manufactured products in the EU and imported products, the elasticity of substitution could be less than 1.4, may even be close to 1.0.

Imbs and Méjean (2010) have made estimates of import demand elasticity for several countries. Their estimates for European countries are relatively low: -0.9 for Greece and Austria, -1.0 for Sweden, -1.3 for Hungary, -1.4 for Norway, -1.5 for U.K., -1.6 for Portugal, -1.7 for Germany, -1.8 for France and -1.9 for Spain. These estimates of import demand elasticity point towards a relatively low elasticity of substitution between domestic production and imports than assumed in the GTAP database.

Németh et al. (2011) have estimated Armington elasticities for EU-14. According to their estimates the short-run Armington elasticity for manufactured products is 0.92. For energy-intensive manufacturing industries (which includes iron and steel), the elasticity is about 1.68 and that for other manufactured products is 0.85. These estimates indicate that the elasticity of substitution between domestic products and imports in EU manufacturing industry is lower than the elasticity in the GTAP database.

For I&S products, several estimates of Armington elasticity are available. Some of them are less than two. The estimate of Armington elasticity made by Gallaway et al. (2003) is about two, which is lower than the estimate in the GTAP database. The elasticity estimates made by Welsch (2008) for Germany also point in the same direction.

Considering the above points about estimates of trade elasticities available in the literature and those in the GTAP, the authors have estimated the elasticity values for the I&S industry using the WITS database. The estimated elasticity is for the EU market. To make the estimate, the value and quantity of the import of I&S by the EU from different trading partners has been sourced from 2012 to 2023. Further, the data is used to estimate the regression equation stated below:

$$ln\left(\frac{Qty_i}{Qty_j}\right) = \beta_o + \beta_1 \ln\left(\frac{Price\ per\ unit_i}{Price\ per\ unit_j}\right) + \theta_{ij} + \varepsilon$$

where Qty_i and Qty_j is the quantity of I&S imported by EU from countries i and j, respectively. Furthermore, the *Price per unit$_i$ and Price per unit$_j$* are unit prices obtained by dividing the import value by the import quantity. θ_{ij} controls for the pair effects between country i and j. Due to the possibility of reverse causation under which the relative quantity might also affect the relative price, we use the instrumental variable regression approach for estimating the elasticity parameter β_1. The relative unit price variable has been instrumented by two period-lagged values of itself as the past relative per unit price is unlikely to affect the future relative quantity.

The estimated elasticity, denoted as β_1, represents the CES elasticity of import demand across sources. By dividing these values by 2, we obtain the CES elasticity between domestic and imported goods. Using these values and a relative adjustment method, we calculate the updated elasticity values for two I&S-related sectors: fabricated metal products and non-ferrous metals. As noted earlier, the GTAP database applies a standard elasticity parameter for each sector across all countries without differentiating between developed and developing nations. Here, we substitute the values estimated for the EU with those for four other major developed countries: Australia, Japan, the United States, and the United Kingdom. The revised elasticity values are shown in the table below:

Table A1: Trade elasticity values: Default vs Estimated values

	GTAP Default Values		Estimated values	
Sector	ESUBD	ESUBM	ESUBD	ESUBM
Iron and Steel (I_s)	2.95	5.9	0.695	1.396
Non-Ferrous Metals (Nfm)	4.2	8.4	0.989	1.993
Fabricated Metal Products (Fmp)	3.75	7.5	0.883	1.780

Source: Authors' estimates

Appendix 3: GTAP Sectors and Regions

Table A2: Mapping model and GTAP Region

S. No.	Model Region Alias	Model Region Description	Original GTAP Regions
1	Argentina	Argentina	Argentina.
2	Australia	Australia	Australia.
3	Brazil	Brazil	Brazil.
4	Canada	Canada	Canada.
5	China	China	China.
6	EU27	EU27	Austria; Belgium; Bulgaria; Croatia; Cyprus; Czech Republic; Denmark; Estonia; Finland; France; Germany; Greece; Hungary; Ireland; Italy; Latvia; Lithuania; Luxembourg; Malta; Netherlands; Poland; Portugal; Romania; Slovakia; Slovenia; Spain; Sweden.
7	AfricaU	Africa Union	Algeria; Egypt; Morocco; Tunisia; Rest of North Africa; Benin; Burkina Faso; Cameroon; Cote d'Ivoire; Ghana; Guinea; Mali; Niger; Nigeria; Senegal; Togo; Rest of Western Africa; Central African Republic; Chad; Congo; Congo the Democratic Republic ; Equatorial Guinea; Gabon; Rest of South and Central Afri; Comoros; Ethiopia; Kenya; Madagascar; Malawi; Mauritius; Mozambique; Rwanda; Sudan; Tanzania; Uganda; Zambia; Zimbabwe; Rest of Eastern Africa; Botswana; Eswatini; Namibia; Rest of South African Customs .
8	India	India	India.
9	Indonesia	Indonesia	Indonesia.
10	Japan	Japan	Japan.
11	Korea	Korea	Korea.
12	Mexico	Mexico	Mexico.
13	Russia	Russian Federation	Russian Federation.
14	SaudiArabia	Saudi Arabia	Saudi Arabia.
15	SouthAfrica	South Africa	South Africa.
16	Turkey	Turkey	Turkey.
17	UK	United Kingdom	United Kingdom.
18	USA	USA	United States of America.
19	CBAMExempt	CBAM Exempt Countries	Switzerland; Norway; Rest of EFTA.
20	Singapore	Singapore	Singapore.
21	Ukraine	Ukraine	Ukraine.
22	Chile	Chile	Chile.
23	Colombia	Colombia	Colombia.
24	EastAsia	East Asia	Hong Kong; Mongolia; Taiwan; Rest of East Asia; Brunei Darussalam.
25	SEAsia	Southeast Asia	Cambodia; Lao People's Democratic Republ; Malaysia; Philippines; Thailand; Viet Nam; Rest of Southeast Asia.
26	SouthAsia	South Asia	Afghanistan; Bangladesh; Nepal; Pakistan; Sri Lanka; Rest of South Asia.
27	LatinAmer	Latin America	Bolivia; Ecuador; Paraguay; Peru; Uruguay; Venezuela; Rest of South America; Costa Rica; Guatemala; Honduras; Nicaragua; Panama; El Salvador; Rest of Central America; Dominican Republic; Haiti; Jamaica; Puerto Rico; Trinidad and Tobago; Caribbean.
28	MiddleEast	Middle East	Bahrain; Iran Islamic Republic of; Iraq; Israel; Jordan; Kuwait; Lebanon; Oman; State of Palestine; Qatar; Syria; United Arab Emirates; Rest of Western Asia.
29	RestofWorld	Rest of World	New Zealand; Rest of Oceania; Rest of North America; Albania; Serbia; Belarus; Rest of Eastern Europe; Rest of Europe; Kazakhstan; Kyrgyztan; Tajikistan; Uzbekistan; Rest of Former Soviet Union; Armenia; Azerbaijan; Georgia; Rest of the World.

Table A3: Mapping model and GTAP Sector

S. No.	Model sector alias	Model Sector Description	Original GTAP sectors
1	Agr	Agriculture and allied sectors	Paddy rice; Wheat; Cereal grains nec; Vegetables, fruit, nuts; Oil seeds; Sugar cane, su Crops nec; Bovine cattle, sheep and goats; Animal products nec; Raw milk; Wool, silk-w Fishing.
2	Coal	Coal Mining	Coal.
3	Oil	Crude oil	Oil.
4	Gas	Natural gas extraction	Gas; Gas manufacture, distribution.
5	Oxt	Other Extraction	Minerals nec.
6	Fpr	Food products,beverages	Bovine meat products; Meat products nec; Vegetable oils and fats; Dairy products; Pro products nec; Beverages and tobacco products.
7	Twl	Textiles, apparel, leather	Textiles; Wearing apparel; Leather products.
8	WoodPaper	Wood and Paper	Wood products; Paper products, publishing.
9	Oil_pcts	Refined oil products	Petroleum, coal products.
10	Chm	Chemical Products	Chemical products.
11	Bph	Pharmaceutical Products	Basic pharmaceutical products.
12	Rpp	Rubber and Plastics	Rubber and plastic products.
13	Nmm	Mineral products nec	Mineral products nec.
14	I_s	Iron and Steel	Ferrous metals.
15	Nfm	Metals nec	Metals nec.
16	Fmp	Metal Products	Metal products.
17	Ele	Computer,electronic and optical products	Computer, electronic and optic.
18	Eeq	Electrical equipment	Electrical equipment.
19	Ome	Machinery nec	Machinery and equipment nec.
20	Mvh	Motor Vehicles and Parts	Motor vehicles and parts.
21	Otn	Transport eq nec	Transport equipment nec.
22	Omf	Manufactures nec	Manufactures nec.
23	Electricity	Electricity	Electricity.
24	Cns	Construction	Construction.
25	Tpt	Transport	Transport nec; Water transport; Air transport.
26	Ser	Services	Water; Trade; Accommodation, Food and servic; Warehousing and support activi; Com nec; Insurance; Real estate activities; Business services nec; Recreational and other se defe; Education; Human health and social work a; Dwellings.

LATEST ICRIER'S WORKING PAPERS

NO.	TITLE	AUTHOR	YEAR
432	CHINA'S MERCANTILIST SQUEEZE ON DEVELOPING COUNTRIES	SHOUMITRO CHATTERJEE ARVIND SUBRAMANIAN	MAY 2026
431	CLEAN ENERGY EMPLOYMENT IN INDIA: A STATE LEVEL ANALYSIS OF NON-FOSSIL FUEL ENERGY SOURCES AND ENERGY EFFICIENCY	AMRITA GOLDAR SOMIT DASGUPTA SAJAL JAIN DIYA DASGUPTA	MARCH 2026
430	HORIZONTAL AND VERTICAL CONNECTOR COUNTRIES IN A GEOECONOMICALLY FRAGMENTING WORLD	SHEKHAR AIYAR FRANZISKA OHNSORGE HAKAN YILMAZKUDAY	MARCH 2026
429	UNRAVELLING INDIA'S E-WASTE SUPPLY CHAIN: A COMPREHENSIVE ANALYSIS AND MAPPING OF THE KEY ACTORS INVOLVED	AMRITA GOLDAR KARTIK NAIR MD SARWAR ALI RITIKA VERMA	NOVEMBER 2025
428	MACROECONOMIC DEVELOPMENTS AND POLICIES SINCE 2000	SHANKAR ACHARYA	MAY 2025
427	INSPECTING THE IMPACT OF FINANCIAL INCLUSION ON EMISSIONS IN INDIA: THE BANKING CHANNEL	SAON RAY VASUNDHARA THAKUR	MARCH 2025
426	E-COMMERCE IN TRADE AGREEMENTS: INDIA'S STRATEGIES AND OPTIONS	ARPITA MUKHERJEE PRITAM BANERJEE AAHANA SRISHTI	JANUARY 2025
425	TOWARDS GREATER REGULATORY CO-OPERATION IN THE ASIA-PACIFIC FOR BOOSTING E-COMMERCE TRADE	ARPITA MUKHERJEE KETAKI GAIKWAD AAHANA SRISHTI	OCTOBER 2024
424	MAKING STATE CIRCULAR ECONOMY PARKS WORK FOR INDIAN STATES (PART 2): AN ECONOMIC ANALYSIS USING THE ICRIER'S SAMPADA WSUT MODEL	AMRITA GOLDAR SAJAL JAIN RITIKA VERMA KARTIK NAIR	JUNE 2024
423	MAKING STATE CIRCULAR ECONOMY PARKS WORK FOR THE INDIAN STATES (PART 1): AN EMERGING STORY OF RAJASTHAN	AMRITA GOLDAR RITIKA VERMA TARUN MALAY KOTAL	JUNE 2024
422	ESTIMATING LOSS AND DAMAGE FROM CLIMATE-INDUCED DISASTERS: AN EVALUATION USING ICRIER 'PRAKRITI' MODEL	AMRITA GOLDAR SAJAL JAIN DIYA DASGUPTA	MAY 2024
421	DECOMMISSIONING OF COAL-BASED PLANTS IN INDIA AND ITS RAMIFICATIONS	SOMIT DASGUPTA	MAY 2024

About ICRIER

Indian Council for Research on International Economic Relations (ICRIER) is an independent public policy organization known for providing informative and insightful ideas to accelerate India's inclusive development. Established in 1981 with the motto of "linking India with the world," it has grown to become one of India's most well-known policy research think tanks in the areas of Agriculture, Climate Change, Digital Economy, Economic Growth, Jobs and Gender, and Trade, Industry and Investment. While serving as a trusted advisor to the governments, corporates, multilaterals and foundations, ICRIER continues to function as a bridge between the academic world and the policy arena.

ICRIER has two office locations in Delhi; in the institutional complex of India Habitat Centre and a new office at the Institutional Area, Sector 6, Pushp Vihar, New Delhi.

ICRIER's Board of Governors include leading academicians, policymakers, and representatives from the private sector. Mr. Pramod Bhasin is ICRIER's Chairperson and Dr. Shekhar Aiyar is Director & Chief Executive.

ICRIER conducts thematic research in the following five thrust areas:

1. Growth, Employment and Macroeconomics (GEM)
2. Trade, Investment and External Relations (TIER)
3. Agriculture Policy, Sustainability and Innovation (APSI)
4. Digital Economy, Start-ups and Innovation (DESI)
5. Climate Change, Urbanization and Sustainability (CCUS)

To effectively disseminate research findings, ICRIER organises workshops, seminars and conferences to bring together academicians, policymakers, representatives from industry and media to create a more informed understanding on issues of major policy interest. ICRIER routinely invites distinguished scholars and policymakers from around the world to deliver public lectures and give seminars on economic themes of interest to contemporary India.

ICRIER