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Agaran Analytics

Research Article

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Posted Date: October 20th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-11406718/v1>

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Additional Declarations: No competing interests reported.

Does the EU Carbon Border Adjustment Mechanism reduce India's engineering exports? Evidence from monthly product-level data

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Abstract

The European Union's (EU) Carbon Border Adjustment Mechanism (CBAM) began with a reporting phase in October 2023 and has required payment since January 2026. Evidence on India comes mainly from sector models and steel producers, and the engineering exporters, many of them micro, small and medium enterprises (MSMEs), have received little attention. This paper estimates the effect of CBAM coverage on India's monthly exports of engineering goods to Europe from January 2022 to July 2026, using official data from India's Department of Commerce. A difference-in-differences design compares five engineering product groups already inside CBAM, such as fasteners and aluminium articles, with seven similar groups outside it. Exports of covered products fell by 11.5 per cent relative to the controls during the reporting phase and by 18.2 per cent once payment began. The fall is largest for fasteners, at 22–27 per cent, and products proposed for coverage only in 2028 show no change. Because the decline started before any payment fell due, data and compliance demands, as well as the carbon price, appear to matter. The paper also compares published model estimates for Indian steel, which range from 58 per cent to almost nothing, and shows with a constant-elasticity calculation that the trade elasticity assumed explains most of the spread. The observed fall for fasteners matches the low elasticities estimated for EU imports. The results support targeted help for MSMEs in measuring and verifying embedded emissions before the downstream extension takes effect.

Keywords: Carbon border adjustment mechanism, Difference-in-differences, Engineering exports, Trade elasticity, MSMEs, India–EU trade

JEL Classification: F13, F14, F18, Q56, Q58, L61

1 Introduction

The EU's Carbon Border Adjustment Mechanism (CBAM) puts a carbon price on the emissions embedded in selected imports. After a reporting-only transition that began in October 2023, it entered its definitive period on 1 January 2026, when EU importers started buying CBAM certificates that match the embedded emissions of covered goods (Kher and Gupta 2026). The covered goods are cement, iron and steel, aluminium, fertilisers, electricity and hydrogen (Goldar et al. 2026). The scope is set to widen. The European Commission proposed in December 2025 to add about 180 downstream steel and aluminium products from 1 January 2028 (European Parliamentary Research Service 2026), and on 15 September 2026 the European Parliament adopted a negotiating mandate, by 464 votes to 50 with 159 abstentions, that approves the extension and broadens it further (European Parliament 2026). Trilogue negotiations between Parliament, Council and Commission are still to come, so the final list of products is open.

India has reason to follow these negotiations closely. The EU takes 17–19 per cent of India's merchandise exports, and CBAM commodities form a larger share of India's exports to the EU than of its exports elsewhere (Goldar et al. 2026). Yet the evidence on the consequences leaves three gaps. First, studies of CBAM and India mostly use computable general equilibrium (CGE) models that report results for sectors and for the country, so the engineering firms that buy steel and aluminium appear only as a modelled sector (Goldar et al. 2026). Second, estimates diverge. Studies reviewed by Goldar et al. (2026) put the loss of India's steel exports to the EU anywhere from a negligible amount to 58 per cent, and their own figure is 24 per cent, so a reader cannot tell whether the differences come from data or from assumptions. Third, the useful numbers are scattered across a working paper, a peer-reviewed article, think-tank notes, export-council releases and trade press, and they do not define products or periods in the same way.

Policy choices are being made now. The downstream product list is still being negotiated, and India's own support is being designed at the same time. The Export Promotion Mission, approved with INR 25,060 crore for fiscal years 2025–26 to 2030–31, includes support for export quality and compliance (Press Information Bureau 2025), and the MSME Sustainable (Zero Defect Zero Effect, ZED) Certification scheme subsidises certification costs at 80, 60 and 50 per cent for micro, small and medium enterprises (Ministry of MSME n.d.). Knowing which firms are exposed, and through which channel, tells policymakers where such money does the most. It also tells an exporter how much of its EU business a product list could touch.

This paper adds direct evidence. Its main contribution is an estimate of how CBAM coverage has affected India's exports of engineering goods, using official monthly data by product from January 2022 to July 2026 and a difference-in-differences design that compares covered and uncovered products before and after the reporting and payment phases began. To my knowledge it is the first ex-post product-level estimate for India. The paper also maps the channels through which CBAM reaches engineering exporters, compares the published model estimates and uses a constant-elasticity calculation to show how much of their spread comes from elasticity assumptions, and derives testable implications for firm-level work on

carbon accounting capability. Public data on individual MSMEs do not exist, so the analysis is at the level of products and sectors.

Section 2 reviews the literature, Section 3 describes the data and methods, Section 4 presents the results, and Section 5 discusses them. Section 6 concludes.

2 Background and related literature

2.1 Border carbon adjustment and carbon leakage

A border carbon adjustment charges imports for the carbon a domestic producer would pay under the importer's carbon price, in order to limit carbon leakage to countries with weaker climate policy. The Energy Modeling Forum compared twelve multi-region CGE models in a common exercise and found that border adjustments cut leakage by about a third, from a mean of about 12 to about 8 per cent, and reduced output losses in the domestic energy-intensive industries by almost two-thirds (Böhringer et al. 2012a). The same models show where the cost goes. A border adjustment is the most effective of the anti-leakage instruments they compared, and its gains come with a shift of the burden to exporters in developing countries (Böhringer et al. 2012b), a conclusion that Böhringer et al. (2022) repeat in their later review. Branger and Quirion (2014) reached a similar conclusion in a meta-analysis of leakage estimates and found that model structure, including the Armington elasticities, explains much of the variation between studies. Section 4.4 returns to this point.

Design choices change the outcome. Fischer and Fox (2012) compare border adjustments with output-based rebates and show that their relative performance depends on sector characteristics and trade elasticities, and that an adjustment on imports alone does not protect exporters in third markets. CBAM charges imports and gives no rebate on EU exports. Fontagné and Schubert (2023) review the theory and evidence. On compatibility with World Trade Organization (WTO) rules, Mehling et al. (2019) argue that a narrowly drawn adjustment that allows exporters to report actual emissions and credits foreign carbon prices has a good chance of being WTO-compatible. Cosbey et al. (2019) recommend similar limits and warn early about the administrative cost of accounting for embedded emissions, which is the burden that falls on small exporters. Overland and Sabyrbekov (2022) place India among the countries most likely to oppose CBAM, and India is absent from the companion index of likely supporters (Sabyrbekov and Overland 2024).

2.2 Ex-ante estimates of CBAM's trade effects

Studies of CBAM itself use several classes of model. In a dynamic CGE model, Bellora and Fontagné (2023) find that CBAM reduces leakage but raises the EU carbon price, and that EU users of CBAM goods lose competitiveness because their exports receive no rebate. Zhong and Pei (2022) use a multi-regional input–output model and find that at USD 100 per tonne EU output rises by 0.38 per cent and output in the rest of the world falls by 0.1 per cent in the short run. Perdana and Vielle (2022) find that CBAM cuts the leakage rate by a third by 2040. Korpar et al. (2023), writing in this journal, use a structural gravity model with sectoral carbon intensities and find small effects on global emissions and welfare. Chepeliev (2021) shows that results depend on whether imports are charged at the exporter's carbon intensity or the EU's. Beaufils et al. (2023) trace emissions through the trade

network and show that the burden on partners depends heavily on whether CBAM is extended along value chains. Dechezleprêtre et al. (2025) find for the OECD that CBAM harms EU industries further downstream.

For India the published estimates are those already reviewed by Goldar et al. (2026). He et al. (2022) estimate with a dynamic CGE model calibrated to version 10 of the Global Trade Analysis Project (GTAP) database that India's iron and steel exports to the EU fall by 58 per cent, at a tariff equivalent of about 15 percentage points. Majumder et al. (2024) find a negligible effect on steel exports with GTAP 11, and Ghosh and Verma (2025) find that iron and steel exports to the EU change by -0.29 per cent. Goldar et al. (2026) estimate a fall of 23.94 per cent with the Samriddhi model of the Indian Council for Research on International Economic Relations (ICRIER), an energy-environment version of GTAP (GTAP-E), after replacing default trade elasticities with estimates from EU import data.

2.3 Trade elasticities and the spread of estimates

The elasticity of substitution between suppliers, the Armington elasticity, decides how far a cost shock on one supplier turns into lost sales. Its value is uncertain. Bajzik et al. (2020) collect published estimates in a meta-analysis, correct for publication bias against small estimates and put the corrected value between 2.5 and 5.1, with a median of 3.8. They also find that the data used, including the level of aggregation, shifts the estimates in a systematic way. Imbs and Mejean (2015) show that aggregate elasticities are smaller than the weighted average of sector elasticities because aggregation assumes the sectors are alike. Feenstra et al. (2018) estimate separately the elasticity between home and foreign goods and the elasticity among foreign suppliers and find the first is often lower than the second, so models that set them equal overstate substitution towards domestic producers. Hertel et al. (2007) estimate the GTAP elasticities and propose reporting CGE results with confidence intervals drawn from their distribution. Goldar et al. (2026) apply the same reasoning to CBAM when they explain their lower estimate by lower elasticities. The present paper takes this line further in Section 4.5.

2.4 Exposure of developing countries and India

Exposure depends on more than carbon intensity. Eicke et al. (2021) combine dependence on EU markets, carbon intensity and capacity to decarbonise into a risk index and find the risk concentrated in countries that depend on the EU and have little capacity to cut emissions. Magacho et al. (2023) show that carbon intensity varies widely between countries within the same industry, and Magacho et al. (2024) find that in many developing economies more than 2 per cent of exports and 1 per cent of production are affected by CBAM once indirect exposure through inputs is counted. The variation within industries is the reason the choice between default values and verified actual emissions matters to an exporter. For India, CBAM goods are a small share of total exports but a larger share of exports to the EU (Goldar et al. 2026; Kher and Gupta 2026).

2.5 Early ex-post evidence

Evidence from the reporting phase is beginning to appear. Vríz et al. (2026) link Indian steel exporters' shipment records to facility-level estimates of emissions and production. They find that high-emission firms cut both export quantities and

revenues to the EU during the CBAM reporting phase, while low-emission firms kept their export levels. Their data also show that the direct emission intensity of India's three main steel product categories is 2.6–2.7 times that of the EU27. An earlier summary of the same research reports lower unit prices for high-emission firms and some pricing power for low-emission firms (Vriz et al. 2025).

Aytun et al. (2026) study Turkish manufacturers with difference-in-differences models. Firms with higher exposure to CBAM-covered exports before the announcement later exported less to the EU and more to other markets: a one standard deviation increase in exposure is associated with 3.2 per cent lower CBAM exports to the EU and 5.5 per cent higher CBAM exports to non-EU destinations, with no matching change in export prices. Keles (2026), using monthly trade for 20 non-EU exporters, finds that exports of products proposed for the 2028 extension rose after October 2023, almost entirely to non-EU markets.

These studies show that exposure alone does not decide outcomes. In India, emission intensity separated the firms that kept EU sales from those that lost them. In Turkey and in the multi-country panel, firms moved markets. None of them measures the capability that lets a firm prove its emissions, which is the gap this paper's propositions address.

2.6 Capabilities, carbon accounting and supplier data

Dynamic capabilities theory describes how firms sense change, seize opportunities and reconfigure resources to keep performing when their environment shifts (Teece et al. 1997; Teece 2007). The natural resource-based view adds that capabilities built around environmental constraints can become sources of advantage (Hart 1995). Martín-Tapia et al. (2008) find that a proactive environmental strategy is related to export intensity among Spanish small and medium enterprises (SMEs), and Leonidou et al. (2013) link an eco-friendly export marketing strategy to export performance. Böttcher and Müller (2015) study low-carbon operations among German automotive suppliers. Singh et al. (2024) study 227 SMEs and treat green export readiness as the step between institutional support and export performance.

Carbon accounting capability is the CBAM-specific form of these capabilities. It covers measuring embedded emissions, reporting and verifying them, and tracing them through the supply chain. CBAM filings rest on installation-level data, and buyers can only use data they trust. Indian evidence on small firms is thin. Naik and Bagodi (2021) found ample unused scope for energy savings in three Indian SME clusters. Gupta and Subramanian (2026) compare 46 ZED-certified and 46 uncertified manufacturing MSMEs in Haryana and find that awareness of sustainability and earlier experience with certification explain adoption better than visible firm characteristics. A discussion paper from SAMEEEKSHA (2025), drawing on export-oriented engineering MSMEs, reports that firms lack training in calculating embedded emissions and find the CBAM reporting template hard to use without support. That paper is not peer-reviewed, and no peer-reviewed study of Indian engineering MSMEs under CBAM was found.

2.7 Buyer pressure and institutional support

Institutional pressure from customers shapes how far suppliers adopt environmental practices. Zhu and Sarkis (2007) show that institutional pressures moderate the link between green supply chain practices and performance, and Sarkis et al. (2010)

show that stakeholder pressure drives adoption. In India, Mohanty and Prakash (2014) find that external pressure on MSMEs to adopt green supply chain practices works entirely through internal pressures such as training. In global supply chains, suppliers without their own climate incentives respond mainly to pressure from buyers (Villena and Dhanorkar 2020), and suppliers whose customers disclose more emit less (Song et al. 2024). Under CBAM, EU importers are the channel through which the regulation reaches a supplier, so buyer pressure is the natural condition to examine. Export promotion programmes work on the resources and capabilities of firms and, through them, on strategy and performance (Leonidou et al. 2011). Whether Indian support schemes do this for carbon accounting is untested.

2.8 Testable implications

The evidence supports four propositions. They are framed as propositions because the secondary data in this paper cannot test them at the firm level.

P1. Among exporters with similar emission intensity, those with stronger carbon accounting capability (measurement, verification and traceability) keep more of their EU export volume under CBAM. The basis is the differentiation by emissions in Vriza et al. (2026): a firm that can verify a low figure should be treated as low-emission, and one that cannot may be treated as high-emission by default.

P2. Green compliance readiness, meaning certified and documented processes and supplier data systems, carries part of the effect in P1. The basis is the mediating role of readiness in Singh et al. (2024).

P3. EU buyer pressure strengthens the link between carbon accounting capability and compliance readiness, because buyers set the form in which data must be supplied (Zhu and Sarkis 2007; Sarkis et al. 2010).

P4. Government support strengthens the link between readiness and export performance only where uptake of schemes is high. The basis is the argument of Leonidou et al. (2011), and the proposition is deliberately weaker than the others because the evidence for support as a moderator is mixed.

3 Data and methods

3.1 Design

The study combines a difference-in-differences estimate on official monthly trade data with an analysis of published secondary evidence. It uses only public sources, and every derived figure in Section 4 is recomputed from the published numbers, with the formulas stated, so that a reader can repeat the calculation. In line with Section 1, the difference-in-differences estimate is the main test, exposure indicators and the cross-study comparison with the constant-elasticity check support it, and the propositions in Section 2.8 set out what firm-level work should test next.

3.2 Data sources and evidence grading

Each source was graded by type. Grade A covers peer-reviewed articles and official or legislative records. Grade B covers working papers and think-tank reports. Grade C covers trade-press reports of figures whose original source could not be opened. Conclusions that rest only on Grade C figures are flagged where they appear. Table 1 lists the sources. The Global Trade Research Initiative (GTRI) and the Engineering Export Promotion Council of India (EEPC India) figures enter through press reports.

Table 1 Data sources and evidence grades

Code	Source	Content used	Period	Grade
S1	Goldar et al. (2026), ICRIER Working Paper 433	Trade shares from the World Integrated Trade Solution (WITS), CBAM commodity exports, GTAP-E simulation results, elasticity adjustments, EU carbon prices	2017–2023	B
S2	Vriz et al. (2026), <i>Nature Climate Change</i>	Firm-level export response by emission level; emission intensity ratio	CBAM reporting phase to end-2025	A
S3	Aytun et al. (2026), World Bank Policy Research Working Paper 11366	Turkish exporters' response to CBAM exposure	2026 working paper	B
S4	GTRI figures reported by AL Circle (2025) and Energywatch (2025)	Steel and aluminium exports to the EU, FY24 and FY25; price gap	FY24–FY25	C
S5	EEPC India figures reported by IANS (2026)	Engineering exports by destination	April–December 2025	C
S6	Analysis of the Commission proposal reported by Outlook Business (2026)	Value of Indian exports in the downstream scope	From 2028	C
S7	European Parliament (2026); European Parliamentary Research Service (2026)	Legislative path and scope of the extension	2025–2026	A
S8	Press Information Bureau (2025); Ministry of MSME (n.d.)	Support schemes for exporters and MSMEs	2025–2026	A
S9	Ministry of Commerce and Industry (2026), TradeStat Monthly Export Import Data Bank	India's monthly exports to Europe by four-digit HS code, US dollars	January 2022–July 2026	A

Note: FY denotes the Indian fiscal year from April to March; FY25 is April 2024 to March 2025.

3.3 Analytical procedures

Seven procedures were applied.

1. Exposure indicators. Shares and ratios of the form $\text{share} = \text{part} \div \text{whole}$, and the ratio of CBAM goods' share of India's exports to the EU against the share for the rest of the world.
2. Growth and counterfactual decomposition. $\text{Growth} = (\text{value in the later period} \div \text{value in the earlier period}) - 1$. Where a source gave a total and a component growth rate, the earlier component value was recovered as $\text{later value} \div (1 + \text{growth})$, and the remainder was computed by subtraction.
3. Cross-study comparison. Published estimates for India's iron and steel exports to the EU were tabulated with their model, price assumption and elasticity, and compared by ratio.
4. Transmission ratio. The modelled change in EU imports from India for each downstream sector was divided by the change for iron and steel to show how the shock thins along the chain.
5. Diversion count. The modelled change in India's iron and steel exports to each non-EU destination in S1 was counted by sign and summarised by median.

6. Timeline analysis. The EU legislative steps were arranged in date order and checked against the compliance dates that apply to exporters.
7. Constant-elasticity check. In a single-sector Armington setting with full pass-through of a tariff-equivalent cost τ , the proportional fall in imports from a supplier is given by Eq. (1), where σ is the elasticity of substitution between suppliers.

$$L(\tau, \sigma) = 1 - (1 + \tau)^{-\sigma} \quad (1)$$

Eq. (1) is a partial-equilibrium simplification and does not replicate the general equilibrium models in the literature. Its use here is limited to showing how much of the spread between published estimates can be produced by the elasticity alone, and it is the author's own derivation. Inverting it gives the elasticity needed to produce a reported loss at a given cost, $\sigma = -\ln(1 - L)/\ln(1 + \tau)$. The check is used in two ways. First, each published estimate for India is inverted at the tariff equivalent of about 15 per cent reported by He et al. (2022), to find the elasticity it implies. Second, the loss is evaluated across the corrected range of published Armington elasticities in Bajzik et al. (2020), to see where the India estimates sit relative to that range. No tariff equivalent has been published for engineering products, so the check is applied to iron and steel only.

All calculations were run in Python from the figures as published. Where two sources disagreed, both are reported and the analysis uses the one with the higher grade or the more conservative reading.

3.4 Monthly export data and estimation

The causal test uses India's monthly exports to the Europe region in TradeStat, the export data bank of the Department of Commerce (Ministry of Commerce and Industry 2026), by four-digit Harmonized System (HS) heading from January 2022 to July 2026 (S9). Products fall into three groups. The treated group holds the five engineering headings that have been in CBAM since October 2023: tube and pipe fittings (7307), structures (7308), screws, bolts and nuts (7318), other articles of iron or steel (7326) and other articles of aluminium (7616). The control group holds seven engineering headings outside both the current scope and the Commission's proposal: chains (7315), stoves (7321), radiators (7322), taps and valves (8481), bearings (8482), transmission parts (8483) and gaskets (8484). A third group of seven headings that the December 2025 proposal would add (7312, 7314, 7317, 7320, 7323, 7325 and 8302) is used as a placebo. The estimating equation is

$$\ln(X_{pt} + 0.01) = \beta_1 (T_p \times R_t) + \beta_2 (T_p \times P_t) + \alpha_p + \gamma_t + \varepsilon_{pt} \quad (2)$$

where X_{pt} is the value of exports of product p in month t in million US dollars, T_p marks treated products, R_t equals one from October 2023 to December 2025 and P_t equals one from January 2026, and α_p and γ_t are product and month fixed effects. The month effects absorb anything that moves all engineering exports to Europe together, such as exchange rates or European demand. Standard errors are clustered by product. With only twelve clusters, conventional clustered errors can be too small, so p-values are also computed with a wild cluster bootstrap (Cameron et al. 2008) using Rademacher weights and 1,999 replications. Robustness checks use the Poisson pseudo-maximum-likelihood estimator of Santos Silva and Tenreiro (2006), a wider control group of 74 headings in chapters 73 and 82–85 with average

pre-period exports of at least USD 1 million a month, a placebo date of October 2022, and an event study by half-year with the first half of 2023 as the base.

3.5 Limitations of the data

The sources do not contain MSME-level records, so firm-size effects are inferred and not measured. The trade data are at the four-digit level, where some headings mix covered and uncovered items, and the Europe region in TradeStat also includes countries outside the EU that CBAM does not reach; both features bias the estimates towards zero. Several figures come from press reports of think-tank data. The ICRIER simulation uses 2017 as its base year, and its carbon price assumption is USD 86.01 per tonne, the 2022 average. The comparison across studies is indicative because the models differ in more than their elasticities. Section 6 states its conclusions with these limits in mind.

4 Results

4.1 Effect of CBAM coverage on India's engineering exports

Before October 2023 the five covered headings earned India about USD 112 million a month in Europe and the seven control headings about USD 121 million. During the reporting phase the covered headings averaged USD 103 million while the controls rose to USD 131 million, and in the first seven months of 2026 the figures were USD 104 million and USD 156 million. Fasteners alone fell from USD 32.8 million a month to USD 26.5 million and then USD 27.1 million. Table 2 reports the estimates of Eq. (2).

Table 2 Effect of CBAM coverage on India's exports of engineering goods to Europe (per cent change relative to controls)

Specification	Reporting phase (Oct 2023– Dec 2025)	Payment phase (Jan–Jul 2026)
(1) Baseline, five covered vs seven control headings	–11.5 (0.094)	–18.2 (0.031)
(2) Wild cluster bootstrap p-value for (1)	(0.116)	(0.049)
(3) Poisson pseudo-maximum likelihood	–15.1 (0.078)	–28.0 (0.039)
(4) Wider control group, 74 headings	–5.9 (0.395)	–15.6 (0.090)
By heading, baseline controls: fittings (7307)	–11.5 (0.047)	–19.2 (0.012)
Structures (7308)	–5.3 (0.375)	–19.7 (0.010)
Screws, bolts and nuts (7318)	–22.5 (<0.001)	–26.7 (<0.001)
Other articles of iron or steel (7326)	–0.6 (0.922)	–3.2 (0.706)
Other articles of aluminium (7616)	–15.8 (0.005)	–20.5 (0.007)
Placebo: proposed headings, after October 2023	–2.6 (0.734)	
Placebo: covered headings, false date October 2022	–7.5 (0.311)	
Proposed headings, after the December 2025 proposal		–3.0 (0.617)

Note: entries are $100[\exp(\beta) - 1]$; p-values from product-clustered standard errors in parentheses unless stated. Data: S9, 55 months, January 2022 to July 2026. The October 2022 placebo uses pre-October 2023 data only.

Exports of covered products fell relative to the controls once reporting began, and the fall deepened when payment started. The payment-phase estimate is

significant at the 5 per cent level under the wild cluster bootstrap, while the reporting-phase estimate is not, at $p = 0.116$. The Poisson estimates are larger, and the wider control group gives smaller ones, with the payment-phase effect still significant at the 10 per cent level. Four of the five headings move in the same direction, and the exception, 7326, is a mixed heading that includes many articles with little steel cost per unit of value. The placebo tests show no change for products that CBAM did not yet cover, no false effect a year before reporting began, and no anticipation effect so far from the December 2025 proposal.

Fig. 1 shows the timing. The coefficients for 2022 and the second half of 2023 are close to zero, so covered and control products moved together before reporting began. The gap opens in 2024 and widens to about 14–18 per cent from 2025 onwards. The decline began well before any payment fell due.

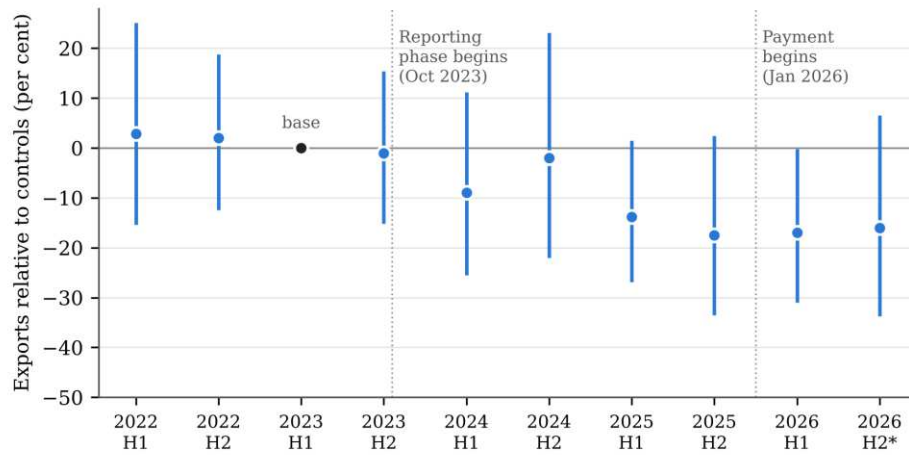


Fig. 1 Event-study estimates of exports of CBAM-covered engineering headings relative to control headings, by half-year, with 95 per cent confidence intervals. Base: first half of 2023. *Second half of 2026 contains July only. Source: author's estimates from S9

4.2 Exposure of India's exports to the EU

Table 3 sets out the exposure indicators. The EU is a large and steady market for India: its share of Indian merchandise exports stayed between 17 and 19 per cent from FY17 to FY22 (S1). CBAM goods matter more to the EU trade than to the rest of the world, at 9 per cent of exports to the EU against 7 per cent elsewhere, a ratio of 1.29 (S1). Within the covered goods the exposure is narrow. Of USD 8.73 billion of CBAM exports to the EU in 2022, iron and steel supplied USD 6.15 billion (70.4 per cent) and aluminium USD 2.57 billion (29.4 per cent), which together make 99.9 per cent. Cement and fertilisers were negligible.

Table 3 Exposure indicators

Indicator	Value	Source
EU share of India's merchandise exports, FY17–FY22	17–19 per cent (average of the six annual shares about 17.7 per cent)	S1
CBAM goods as a share of India's exports to the EU	9 per cent, against 7 per cent to the rest of the world (ratio 1.29)	S1
India's CBAM-commodity exports, 2022	USD 32.2 billion, 27 per cent to the EU (about USD 8.7 billion)	S1
Composition of CBAM exports to the EU, 2022	Iron and steel USD 6.15 billion (70.4 per cent); aluminium USD 2.57 billion (29.4 per cent)	S1
EU share of India's engineering exports, April–December 2025	18.0 per cent (USD 16.34 billion of USD 90.73 billion); 17.2 per cent a year earlier (derived)	S5
Value of Indian exports in the proposed downstream scope	At least USD 1.1 billion: 6.7 per cent of April–December 2025 EU engineering exports, or 5.0 per cent of the annualised figure (USD 21.8 billion)	S5, S6

Source: author's calculations from the sources listed in Table 1.

The current scope already covers some engineering goods directly, among them fittings, structures, fasteners and articles of iron, steel and aluminium, and it reaches the rest through their inputs, since a fabricator that buys steel inherits part of its supplier's carbon cost and data. The proposed extension would add direct obligations for about 180 more products. The figure of 5–7 per cent of EU-bound engineering exports hides concentration: Parliament's mandate adds wire, springs and household articles (European Parliament 2026), and a firm whose catalogue sits in those codes faces far more than the average.

4.3 Early export responses

Table 4 brings together the early responses.

Table 4 Early responses in export data

Indicator	Value	Source
Steel and aluminium exports to the EU, FY24 to FY25	USD 7.71 billion to USD 5.82 billion, a fall of 24.4 per cent	S4
Component changes (reported by one outlet only)	Iron and steel down 35.1 per cent to USD 3.05 billion; aluminium down 9.8 per cent	S4
Engineering exports to the EU, April–December 2025	USD 16.34 billion, up 9 per cent	S5
Total engineering exports, April–December 2025	USD 90.73 billion, up 3.88 per cent	S5
Implied engineering exports to all other destinations	Up 2.8 per cent (derived)	S5
Indian steel exporters by emission level, reporting phase	High-emission firms cut EU quantities and revenues; low-emission firms held their levels	S2

Source: author's compilation and calculations from the sources listed in Table 1.

Upstream, India's steel and aluminium exports to the EU fell 24.4 per cent in FY25, before the payment phase began; Energywatch (2025) gives endpoints of USD 7.71 billion and USD 5.82 billion, and only AL Circle (2025) reports the split between steel and aluminium, which is used here as an indication only.¹ Vríz et al. (2026) find that high-emission producers carried the fall. The steel figures may

¹ The component figures do not reconcile exactly with the totals. With iron and steel at USD 3.05 billion after a 35.1 per cent fall, the totals imply an aluminium fall near 8 per cent against the reported 9.8 per cent.

also reflect anti-dumping and safeguard measures, including provisional duties of 13.6–34.6 per cent on some Indian stainless flat products (AL Circle 2025).

Downstream, total engineering exports to the EU grew 9 per cent in April–December 2025, faster than the 2.8 per cent implied for other destinations. This does not conflict with Section 4.1. Most engineering products are not yet in CBAM, so the aggregate is dominated by uncovered goods, while the covered headings fell.

4.4 Why published estimates differ

Table 5 sets the published estimates side by side, and Fig. 2 plots them against the observed fall.

Table 5 Estimates of CBAM’s effect on India’s exports to the EU

Study	Model and assumptions	Estimate
He et al. (2022)	Dynamic CGE, GTAP 10; tariff equivalent about 15 percentage points for steel	Iron and steel –58 per cent
Goldar et al. (2026), default elasticities	GTAP-E; import substitution elasticity 5.9 (iron and steel)	Large fall, similar to He et al. (not quantified in the paper)
Goldar et al. (2026), estimated elasticities	GTAP-E; carbon price USD 86.01 per tonne; import substitution elasticity 1.396	Iron and steel –23.94 per cent; non-ferrous metals –10.13 per cent; fabricated metal –4.30 per cent
Ghosh and Verma (2025), as reported in S1	CGE; CBAM-driven tax on exports	Iron and steel –0.29 per cent
Majumder et al. (2024), as reported in S1	GTAP 11	Negligible for iron and steel
Observed, GTRI (S4)	Customs data, FY24 to FY25, before the payment phase	Steel and aluminium –24.4 per cent

Source: compiled by the author from Goldar et al. (2026), He et al. (2022) and S4.

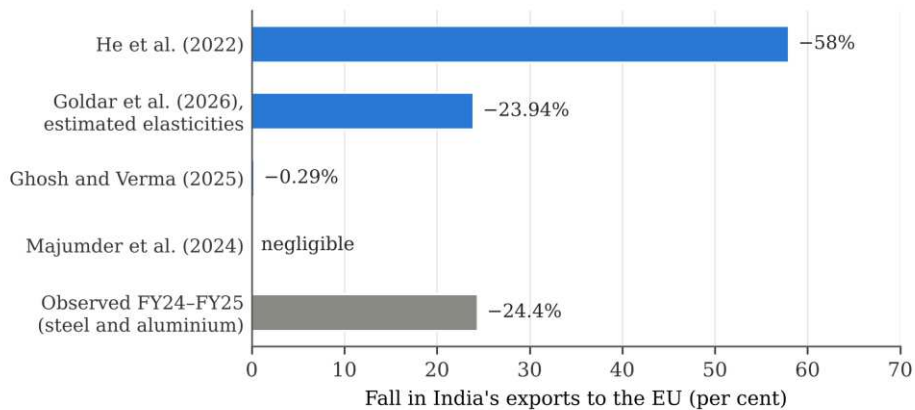


Fig. 2 Published estimates of the fall in India’s iron and steel exports to the EU under CBAM, and the observed fall in steel and aluminium exports, FY24 to FY25. Source: author’s compilation from He et al. (2022), Goldar et al. (2026) and S4. The observed bar covers steel and aluminium together and predates any CBAM payment

The spread between the first and third rows is a factor of 2.4 ($58 \div 23.94$). Goldar et al. (2026) trace it mainly to trade elasticities: their estimated import substitution elasticity for iron and steel is 1.396 against 5.9 in the GTAP default, a cut of 76 per cent, and the elasticity between domestic and imported goods falls from 2.95 to 0.695. With the default values their model also returns a large fall like that of He et

al. (2022). The models differ in other ways too, so the elasticity explanation is indicative.

The observed fall of 24.4 per cent is close to the modelled 23.94 per cent, a gap of 0.5 percentage points. That match is weaker evidence than it looks. The observed figure covers steel and aluminium together, falls before any levy was paid, and mixes in anti-dumping effects, while the modelled figure is for steel at a levy of USD 86.01 per tonne. If the component figures from AL Circle (2025) are right, observed steel fell by more than the model predicts (−35.1 against −23.94 per cent) and aluminium by about the modelled amount (−9.8 against −10.13 per cent). Because those components do not reconcile exactly with the totals, this comparison is only suggestive.

4.5 An illustrative constant-elasticity check

Table 6 gives the fall in imports implied by Eq. (1) for several tariff-equivalent costs and elasticities. The values are illustrative and rest on the stated assumptions.

Table 6 Implied fall in EU imports (per cent) under a constant-elasticity assumption

Tariff-equivalent cost τ	$\sigma = 1.0$	$\sigma = 1.396$	$\sigma = 2.0$	$\sigma = 5.9$
5%	4.8	6.6	9.3	25.0
10%	9.1	12.5	17.4	43.0
15%	13.0	17.7	24.4	56.2
20%	16.7	22.5	30.6	65.9
25%	20.0	26.8	36.0	73.2

Note: author's calculation from Eq. (1), single-sector Armington, full pass-through. $\sigma = 1.396$ and 5.9 are the adjusted and default import-substitution elasticities in Goldar et al. (2026).

At a tariff equivalent of about 15 per cent, the figure reported by He et al. (2022), a 58 per cent loss needs σ of about 6.2, close to the default of 5.9 used in the standard model. The 23.94 per cent loss in Goldar et al. (2026) needs σ of about 2.0 at the same cost, and with their adjusted σ of 1.396 it needs a cost of about 21.7 per cent. A cost of 15 per cent and an elasticity between 2 and 6 therefore reproduce most of the published range. Elasticity choice explains much of the divergence, and the check does not show which value is right. The fastener results in Section 4.1 give one way to choose. India's default value for threaded screws and bolts in the definitive period is 5.72 tonnes of CO₂ per tonne, which becomes 6.29 with the 10 per cent mark-up that applies in 2026.² At the average 2026 CBAM certificate price of EUR 77.65 for the first three quarters (European Commission 2026), an importer relying on the default would owe about EUR 489 per tonne before any deduction for free allocation. Against a unit value of about USD 2,670 per tonne for India's fastener exports in January 2025 (United Nations 2026), this is a tariff equivalent of 20–22 per cent at exchange rates of 1.10–1.20 dollars per euro, an upper bound because the free-allocation deduction is ignored. Eq. (1) then gives a loss of 23–24 per cent with the elasticity of 1.396 that Goldar et al. (2026) estimate for EU imports of iron and steel and 28–30 per cent with their 1.780 for fabricated metal products, against 37–64 per cent across the range in Bajzik et al. (2020). The observed payment-phase fall for fasteners, 26.7 per cent, lies inside the band implied by the low, EU-specific elasticities.

² Commission Implementing Regulation (EU) 2025/2621, as corrected by Implementing Regulation (EU) 2026/1740; the figure is the direct-emission default for CN 7318 15 with India as country of origin.

Fig. 3 traces Eq. (1) over a range of elasticities for three tariff-equivalent costs and marks the two published estimates. Both points sit on the 15 per cent curve. The point for He et al. (2022) lies near the GTAP default elasticity, and the point for Goldar et al. (2026) lies between the estimated and default values, much closer to the estimated one.

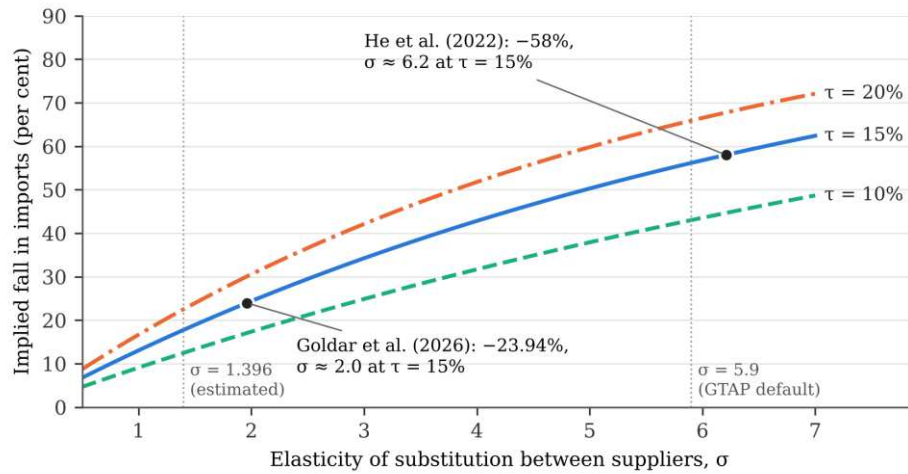


Fig. 3 Implied fall in imports under Eq. (1) by elasticity of substitution and tariff-equivalent cost. Source: author's calculation. Dotted lines mark the estimated (1.396) and GTAP default (5.9) import-substitution elasticities in Goldar et al. (2026)

4.6 Transmission to downstream products

Table 7 reports the modelled change in EU imports from India by sector.

Table 7 Modelled change in EU imports from India by sector (carbon price USD 86.01 per tonne)

Sector (GTAP label)	Change (per cent)	Ratio to iron and steel
Iron and steel	-23.94	1.00
Chemical products (fertilisers)	-16.80	0.70
Non-ferrous metals (aluminium)	-10.13	0.42
Fabricated metal products	-4.30	0.18
Mineral products (cement)	-1.92	0.08
Other extraction	+0.71	not applicable

Source: Goldar et al. (2026); ratios calculated by the author.

The shock thins as goods are processed further. Fabricated metal products, the closest modelled sector to engineering goods, lose 4.30 per cent, which is 18 per cent of the loss in iron and steel (S1). Two reasons are plausible. Embedded emissions are a smaller share of the value of a fabricated product, and the model only prices the emissions of covered inputs. The extension to downstream goods is meant to reduce that gap, so the 2028 list matters more than the current scope.

The model also shows where exports go. Of the 26 non-EU destinations and regions in the simulation, 24 show a rise in India's iron and steel exports; the median change is +0.35 per cent. The largest gain is +3.16 per cent in the CBAM-exempt European countries, followed by Turkey (+1.07 per cent) and South Africa (+0.73 per cent). Only Russia (-0.14 per cent) and Ukraine (-0.88 per cent) fall (S1). The direction agrees with the Turkish evidence, where more exposed firms exported 3.2 per cent less to the EU and 5.5 per cent more elsewhere (Aytun et al. 2026). Market

diversion is therefore a likely response alongside capability building, and any firm-level study must control for it.

At the national level the simulation shows small environmental effects: India's iron and steel emissions fall by 1.57 per cent, global emission intensity in the sector by 0.53 per cent, and EU emissions rise by 0.29 per cent because EU production expands (S1). The trade loss therefore buys little emission reduction, which is the basis for the protectionism argument that Goldar et al. (2026) discuss.

4.7 Carbon accounting capability and policy timing

Table 8 shows the EU carbon permit price over the period covered by the simulation.

Table 8 Annual average EU carbon permit price

Year	USD per tonne of CO ₂	Change on previous year (per cent)
2017	6.64	
2018	18.69	+181.5
2019	27.84	+49.0
2020	28.40	+2.0
2021	62.79	+121.1
2022	86.01	+37.0
2023	101.14	+17.6

Source: Goldar et al. (2026); changes calculated by the author.

The price rose from USD 6.64 in 2017 to USD 101.14 in 2023, a compound annual growth rate of 57.4 per cent, and it tripled between 2020 and 2022 ($86.01 \div 28.40 = 3.03$) (S1). GTRI puts the gap between the EU price of about USD 71 per tonne and India's projected carbon price of under USD 10 at roughly USD 61 per tonne, so India's price is at most about 14 per cent of the EU's (AL Circle 2025). Any exporter whose emissions are not recognised at home pays the difference at the EU border.

Table 9 sets out the regulatory path.

Table 9 Regulatory path and what it means for exporters

Date	Event	Implication for an engineering exporter
October 2023	Reporting-only transition begins (S1)	Buyers start asking for embedded-emission data
December 2025	Commission proposes about 180 downstream steel and aluminium products from 2028 (European Parliamentary Research Service 2026)	Check product codes against the list
1 January 2026	Definitive period starts; importers buy certificates (Kher and Gupta 2026)	Carbon cost is priced into buyer contracts
15 September 2026	Parliament adopts its mandate, 464 for, 50 against, 159 abstentions, and broadens the scope (European Parliament 2026)	The final list may be longer than 180 products
Pending	Trilogue negotiations	Final list and start date not yet fixed
1 January 2028	Proposed start of the extended scope (European Parliament 2026)	Direct obligations on in-scope products

Source: compiled by the author from the sources cited in the table.

Parliament's mandate won 90.3 per cent of the votes cast for or against, which makes a wider list more likely, although the trilogue can still change it. An exporter

that waits for the final list loses the time needed to build measurement and verification routines.

5 Discussion

The results fit a staged view of exposure. In the first stage, carbon-intensive semi-finished goods feel the pressure; Indian steel exports to the EU fell sharply and the firm-level evidence ties the fall to high emission levels (S2, S4). In the second stage, which begins with buyers' data requests and the 2028 extension, downstream firms meet the same logic with less room to absorb cost. The estimates in Section 4.1 show that this second stage has already begun for the engineering goods that CBAM covers today, even though aggregate engineering exports kept growing.

Two features of the estimates bear on the mechanism. The decline began during the reporting phase, before any certificate had to be bought, so the carbon price alone cannot explain it. Reporting obliged EU importers to collect installation-level emissions data from their suppliers, and a buyer facing a supplier that cannot provide such data can switch to one that can. The early fall is consistent with this channel, which is the one P1 and P3 describe, although the trade data cannot separate it from buyers' anticipation of future costs. The second feature is the size of the fall in the payment phase. For fasteners it matches the loss implied by the low EU-specific elasticities in Goldar et al. (2026), which suggests that those elasticities describe EU buyers' behaviour better than the default values in the standard model. Both estimates are probably conservative: the Europe region includes countries outside the EU, and the four-digit headings include uncovered items.

The elasticity results in Section 4.5 also give a way to read the published range. If the import-substitution elasticity for Indian steel lies within the corrected range of 2.5–5.1 that Bajzik et al. (2020) report across published studies, Eq. (1) puts the loss at a 15 per cent tariff equivalent between 29.5 and 51.0 per cent, and at 41.2 per cent for their median of 3.8. Both quantified CGE estimates for India sit outside that band, one above it and one below. The calculation is partial equilibrium, but it suggests that neither figure should be treated as a central case. The small aggregate effects found in gravity and input–output models (Zhong and Pei 2022; Korpar et al. 2023) do not contradict a large sectoral loss: CBAM goods are a small share of India's exports, so a large fall in steel can coexist with a negligible effect on national income.

For P1, the key finding of Vríz et al. (2026) is that emission level separated the firms that kept their EU sales from those that lost them. The CBAM framework supplies a default determination of embedded emissions when precise data are missing (AZB & Partners 2024), which means a firm that cannot document its emissions may be assessed as if it were a high emitter. That is the mechanism behind P1: measurement, verification and traceability let a firm replace a default with its own figure. The secondary data cannot show how many MSMEs have this capability, which is why P1 remains a proposition.

How much this capability is worth depends on two provisions of the regulation. The first is the use of default values when actual emissions are not documented. Carbon intensity varies widely within industries (Magacho et al. 2023), so a low-emission supplier without documented data loses the advantage its technology should give it. The second is the deduction for a carbon price paid in the country of

origin, which Regulation (EU) 2023/956 allows (European Union 2023). With GTRI projecting an Indian carbon price below USD 10 per tonne against an EU price of about USD 71 (AL Circle 2025), the deduction would be small for now, but it would grow if India's domestic price rose. Both provisions require verified data (Cosbey et al. 2019; Mehling et al. 2019), and for an engineering MSME those data come largely from its steel, aluminium and electricity suppliers, so supplier data are part of the capability in P1.

For P2 to P4, the secondary evidence is indirect. Readiness as a bridge between support and export outcomes has precedent in SME research (Singh et al. 2024), and buyer pressure is how CBAM reaches suppliers. For support schemes, the Export Promotion Mission includes compliance support and ZED subsidies cover most certification costs (Press Information Bureau 2025; Ministry of MSME n.d.), but nothing in the sources shows how many exporting MSMEs use them. Goldar et al. (2026) recommend this kind of support, and P4 therefore concerns the uptake of schemes.

Indian studies of small firms point to where the constraint lies. Gupta and Subramanian (2026) found that awareness and earlier certification experience explained ZED adoption better than firm size or other visible traits, and Mohanty and Prakash (2014) found that external pressure on MSMEs worked only through internal factors such as training. The SAMEEEKSHA (2025) discussion paper reports that engineering exporters lack training in emission calculation. Read together, these findings suggest that subsidising the cost of certification may not be enough if firms do not know what data they need, and that training and awareness belong in any test of P4.

The Turkish evidence adds a caution, and the multi-country panel of Keles (2026) adds a downstream example: products in the proposed 2028 scope were already being sent to non-EU markets after October 2023. If exposed firms mostly redirect exports, capability building is only one of several responses, and a firm-level test of P1 to P4 should record non-EU sales and whether the firm's products fall within the covered or proposed codes.

6 Conclusion

This study asked how the EU's Carbon Border Adjustment Mechanism reaches Indian engineering exporters. Official monthly data show that it already has. India's exports to Europe of the engineering goods covered since 2023 fell by 11.5 per cent relative to similar uncovered goods during the reporting phase and by 18.2 per cent once payment began, with fasteners down by about a quarter. Products that CBAM does not yet cover show no change. The decline started before any payment, which points to the data and compliance demands of the reporting phase as well as to the carbon price. Published model estimates for steel differ by a factor of about 2.4, largely because of the trade elasticities assumed, and the observed fall for fasteners is in line with the low elasticities estimated for EU imports.

6.1 Implications for policy

The compliance support that already exists should be aimed at firms whose product codes appear in the Commission's list and in Parliament's wider mandate. Goldar et al. (2026) call for standardised measurement protocols, digital traceability and

dedicated compliance help for MSMEs, and the Export Promotion Mission and ZED subsidies are the channels through which that help can run (Press Information Bureau 2025; Ministry of MSME n.d.). A public tool that lets an exporter check its product codes against the proposed list would cost little and answer the question most firms ask first, whether their products are on the list. Data on how many exporting MSMEs use the schemes should be collected, because without it nobody can tell whether support reaches the exposed firms.

Projections used in trade negotiations should be reported as ranges that reflect elasticity uncertainty (Hertel et al. 2007). In negotiations with the EU, India can seek recognition of domestic carbon pricing under the deduction for carbon prices paid abroad, and the use of CBAM revenue to support decarbonisation in trading partners, which Perdana and Vielle (2022) find raises recipients' welfare at low cost to the EU. The burden on partners also depends on how far the scope is extended along value chains (Beaufils et al. 2023), so for engineering exporters the product list now under negotiation matters at least as much as the carbon price.

6.2 Implications for firms

Exporters should check their codes now, ask EU buyers in what form they want emissions data, and start measuring the emissions in their steel and electricity inputs. Verification is the step that lets a firm replace a default figure with its own. Firms should also compare this investment with the option of selling more outside the EU, which the simulation and the Turkish evidence both suggest is a common response.

6.3 Limitations and future research

The difference-in-differences estimates rest on twelve product groups and one destination region, so a demand shock specific to covered products in Europe could not be ruled out, and a comparison with exports of the same products to non-EU markets would strengthen the identification. The trade data are at the four-digit level and in values only. The other sources contain no MSME-level records, some series come from press reports of think-tank data, and the ICRIER simulation uses a 2017 base year and a single carbon price. The propositions about carbon accounting capability are untested. The legislative path may change at trilogue, and the figures here reflect the position in October 2026.

The propositions can be tested with a survey of engineering exporters with active EU sales, measuring carbon accounting capability, compliance readiness, EU buyer pressure and government support, with controls for firm size, non-EU sales and whether products fall under the current or proposed codes. Linking survey responses to shipping-bill data would give an objective export outcome and reduce reliance on single respondents. At the product level, the design used here should be extended to eight-digit products and to non-EU destinations as a triple difference, following Keles (2026), and updated when the trilogue fixes the final product list. Elasticities for engineering products at the six-digit level would also help, since aggregate elasticities understate the variation between sectors (Imbs and Mejean 2015).

Declarations

- **Funding** The author did not receive support from any organisation for the submitted work.

- **Competing interests** The author has no relevant financial or non-financial interests to disclose.
- **Ethics approval and consent to participate** Not applicable. The study uses published secondary data and involves no human participants.
- **Consent for publication** Not applicable.
- **Data availability** All data analysed in this study are publicly available from the sources listed in Table 1 and the reference list. The derived indicators can be recomputed from the figures reported in Tables 2–9.
- **Materials availability** Not applicable.
- **Code availability** The Python calculations are simple arithmetic on published figures and are available from the corresponding author on request.
- **Author contribution** K. Praveenkumar conceived the study, collected and analysed the data, and wrote the manuscript.

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