

Beyond the Green Facade: Anticipatory Trade Responses to the Carbon Border Adjustment Mechanism

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Abstract

We examine whether the European Union's Carbon Border Adjustment Mechanism (CBAM) generated anticipatory trade responses prior to implementation. Using bilateral monthly trade data from EU COMEXT between 2018 and 2023, we estimate an event-study specification comparing CBAM-covered sectors to non-CBAM-covered sectors across advanced and emerging market exporters to the EU. We find evidence of export frontloading following the announcement of CBAM, particularly among emerging market economies, with exports in CBAM-covered sectors rising by approximately 42–49 percent relative to non-CBAM-covered sectors within three quarters of the announcement. No comparable response is detected for advanced economies. The results suggest that climate-linked trade policy can influence international trade flows well before formal enforcement begins.

Keywords: CBAM, Trade Policy, Climate Policy, European Union

JEL Codes: F13, Q56, F18, Q58

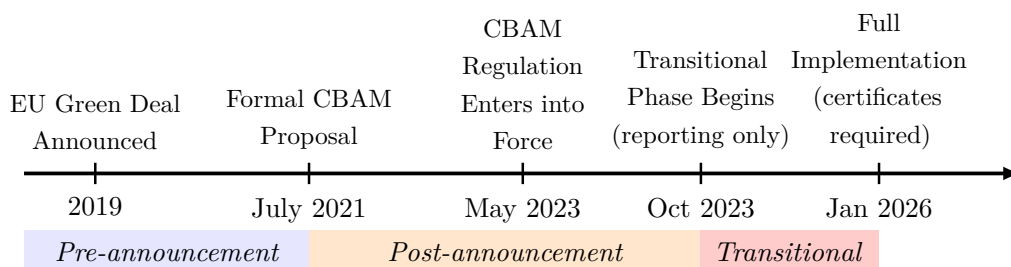
1 Introduction

As part of its European Green Deal, the EU has moved aggressively to align its trade policy with its climate ambitions. Central to this effort is the Carbon Border Adjustment Mechanism (CBAM), an extension of the EU Emissions Trading System (ETS) to imported goods. Under the ETS, EU producers in carbon-intensive sectors must purchase allowances for each tonne of CO₂ they emit, raising their production costs relative to foreign competitors not subject to equivalent carbon pricing. Without a border measure, this creates an incentive for production to shift to lower-regulation jurisdictions while undermining the competitiveness of EU producers. CBAM addresses this by requiring EU importers to surrender certificates corresponding to the embedded emissions of imported goods, with the certificate price linked to the prevailing EU ETS carbon price.¹ Crucially, importers may deduct any carbon price already paid by the producer in its country of origin, creating a direct incentive for exporting countries to introduce or strengthen domestic carbon pricing mechanisms.

CBAM currently covers five carbon-intensive sectors: iron and steel, cement, fertilizers, aluminum, and electricity. Beyond the certificate purchase itself, exporters must support EU importers with Monitoring, Reporting, and Verification (MRV) of embedded emissions, a requirement that functions as a non-tariff measure and imposes asymmetric costs on producers in countries with less developed carbon accounting infrastructure. These compliance burdens fall disproportionately on developing economies, for which the EU represents a critical export destination. For countries such as India, Egypt, and Ukraine, the EU accounts for a significant share of sectoral export revenue in iron and steel, aluminum, fertilizers, and cement, making the cost implications of CBAM particularly consequential. The timeline of implementation is summarized in Figure 1.

¹A simplified representation of the CBAM certificate calculation is provided in Appendix A.

Figure 1. Key legislative and regulatory milestones in the rollout of CBAM.



A distinctive feature of CBAM’s design is that financial liability is prospective. The full certificate surrender requirement does not apply until January 2026, yet the policy was formally proposed in July 2021 and entered into force in May 2023. This extended pre-enforcement window creates conditions under which rational, forward-looking EU importers may adjust their sourcing behaviour well before any financial obligation materialises, with direct consequences for export flows from developing economies. Importers seeking to minimise future compliance costs may begin shifting sourcing toward lower-emission suppliers upon announcement, reducing exports from carbon-intensive countries. Alternatively, they may frontload purchases of CBAM-covered goods ahead of the point at which certificate obligations become financially binding, temporarily increasing export flows. Both mechanisms imply that the announcement itself constitutes a meaningful economic shock to trade flows, with the direction of the response an empirical question.

This paper addresses that question directly. Using monthly bilateral trade data from Eurostat’s COMEXT database covering 2018–2023, we estimate an event-study specification comparing CBAM-covered to non-covered sectors within the same country, exploiting within-country sectoral variation in CBAM exposure. We find evidence of frontloading concentrated among emerging market exporters, with exports in CBAM-covered sectors rising by approximately 42–49 percent relative to non-covered sectors within three quarters of the announcement. No comparable response is detected for advanced economies, consistent with these exporters facing lower expected compliance costs. The results suggest that climate-linked trade policy can reshape trade flows through expectations alone, well before formal enforcement begins.

The remainder of the paper is structured as follows: Section 2 reviews the related literature. Section 3 describes the data and panel construction. Section 4 presents the empirical methodology. Section 5 discusses the results. Section 6 outlines policy

implications, and Section 7 concludes.

2 Related Literature

A broad literature examines how regulatory standards and non-tariff measures affect international trade. Technical barriers and compliance requirements can raise exporters' costs and restrict market access, influencing both export participation and trade volumes. Empirical evidence suggests that such regulatory shocks can significantly reshape export behavior. Wei et al. (2023) show that stringent technical barriers to trade increase compliance costs and induce firms to adjust their export strategies, either by upgrading product quality to remain in the regulated market or by reallocating exports toward alternative destinations. Similarly, research on non-tariff measures finds that additional compliance requirements can affect both the intensive and extensive margins of trade, leading countries to export fewer products and lower quantities to more regulated markets (Nabeshima et al., 2021).

More recently, a growing literature has examined the economic implications of carbon border adjustment policies. Several studies rely on simulation or general equilibrium models to estimate the potential impact of CBAM on trade flows and competitiveness. For instance, Li et al. (2026) find that CBAM may reduce export competitiveness for carbon-intensive exporters, particularly in developing economies. At the policy level, reports by the World Bank (2023) and OECD (2025) similarly suggest that countries with carbon-intensive industrial structures may face higher adjustment costs under CBAM.

While these studies provide insights into the potential long-run effects of CBAM, much of the existing literature relies on simulations or exposure measures rather than observed trade outcomes. Consequently, there is limited empirical evidence on whether trade flows have already begun adjusting following the policy's announcement. This paper contributes to the emerging empirical literature on climate-related trade policies by examining whether exports to the EU changed following the announcement of CBAM, exploiting variation in country–sector-level CBAM exposure.

3 Data and Panel Construction

The primary source of data for this analysis is Eurostat’s COMEXT database (EUR-Lex, 2023), which provides monthly bilateral trade flows between the EU and its trading partners at the CN8-digit commodity level.² From this, we construct a quarterly panel at the country–sector level of export flows from all CBAM-exposed countries to the EU, covering 2018–2023. This window captures both the pre-announcement baseline and two post-treatment periods: the formal CBAM proposal in July 2021, and the transitional implementation phase in October 2023. We then use European Commission’s CBAM Guidelines from 2021 (Council of the European Union, 2021) to obtain the list of products covered under CBAM at the CN8 level, and classify each code into one of four³ CBAM-covered sectors: iron and steel, cement, fertilizers, and aluminium.⁴ For chapters that contain CBAM-covered products, we retain only those CN8 codes that map to a CBAM sector, ensuring that non-covered products within mixed chapters do not dilute the treatment measure. We exclude exports originating from EEA and EFTA countries—Iceland, Liechtenstein, Norway, Switzerland, and the United Kingdom—as these economies participate in the EU Emissions Trading System and are therefore not subject to CBAM. The resulting trade flows are aggregated to a quarterly country–sector panel comprising 68 countries and 98 sectors. We further augment the dataset with the IMF World Economic Outlook country classification to distinguish advanced from emerging market economies; of the 68 countries, 11 are classified as advanced economies and the remainder as emerging markets.

4 Methodology

To examine whether the CBAM announcement affected exports in CBAM-covered sectors, we employ an event-study framework that exploits within-country variation across sectors in their exposure to CBAM. The treatment group comprises the four

²CN8 refers to the Combined Nomenclature at the 8-digit level, the most granular product classification used in EU external trade statistics.

³Electricity is excluded from the empirical analysis due to limited comparability and sparse bilateral trade observations in COMEXT.

⁴Classification uses prefix matching on CN codes, so a 4-digit heading entry (e.g. 7601) covers all 8-digit subheadings beneath it. Three CN codes are explicitly excluded despite falling within CBAM chapters: ferro-alloys (7202), ferrous waste and scrap (7204), and diammonium phosphate (31056000), which are related to covered sectors but not themselves subject to CBAM, and are excluded to avoid confounding.

CBAM-covered sectors—iron and steel, cement, fertilizers, and aluminium—while all remaining sectors in the panel serve as the control group. We estimate the following specification:

$$\log(\text{Value}_{sct}) = \alpha_{sc} + \delta_t + \sum_{\tau \neq -1} \beta_{\tau} (\mathbb{1}\{t = \tau\} \times \text{CBAM}_s) + \varepsilon_{sct}, \quad (1)$$

where s denotes sector, c denotes country, and t denotes quarter. $\log(\text{Value}_{sct})$ is the log of the value of imports (in Euros) from country c in sector s at time t , into the EU. CBAM_s is an indicator equal to one for CBAM-covered sectors. α_{sc} are country-sector fixed effects that absorb all time-invariant differences across country-sector pairs, including structural features of comparative advantage and baseline EU trade intensity. δ_t are time fixed effects that control for common shocks to EU import demand in any given quarter, such as global commodity price movements or EU-wide business cycle fluctuations. ε_{sct} is the error term, and standard errors are clustered at the country level.

The coefficients β_{τ} trace the dynamic treatment effect of CBAM exposure relative to the omitted quarter preceding the July 2021 announcement ($\tau = -1$)⁵. The pre-announcement coefficients ($\tau < -1$) allow us to assess the validity of the parallel trends assumption. If covered and non-covered sectors were evolving symmetrically prior to the July 2021 proposal, these estimates should be statistically indistinguishable from zero. The post-announcement coefficients ($\tau \geq 0$) reveal the timing and persistence of any treatment effect, allowing us to distinguish between an immediate announcement effect and a response concentrated around the onset of the transitional phase in October 2023. Post-announcement coefficients that are negative and statistically significant would indicate a decline in exports from CBAM-covered sectors following the announcement, consistent with EU importers beginning to substitute away from carbon-intensive sources in anticipation of future compliance costs. Positive and statistically significant coefficients, by contrast, would be consistent with frontloading behaviour, whereby EU importers accelerate purchases ahead of the point at which certificate obligations become financially binding.

⁵Although the European Commission formally introduced the CBAM proposal in July 2021, substantial information regarding its design and implementation had already entered the public domain through policy discussions and leaked draft documents during the preceding quarter. To account for potential anticipatory responses by firms and financial markets, and to avoid attenuation or misclassification bias arising from treating already-affected observations as pre-treatment periods, we define the treatment onset as 2021Q2 rather than 2021Q3.

5 Results

5.1 Emerging Markets

Figure 2 plots the $\hat{\beta}_\tau$ coefficients from equation (1) for the emerging market subsample. The pre-announcement coefficients are small and largely indistinguishable from zero, lending support to the parallel trends assumption for this subsample. Following the July 2021 announcement, coefficients turn positive and grow gradually, reaching approximately 0.35–0.40 log points by $\tau = 3$ and remaining elevated through the end of the sample, implying exports in CBAM-covered sectors were around 42–49 percent higher relative to non-covered sectors compared to the pre-announcement period.⁶ This pattern is consistent with frontloading behaviour, whereby EU importers accelerated purchases of CBAM-covered goods from emerging markets in anticipation of future compliance costs.

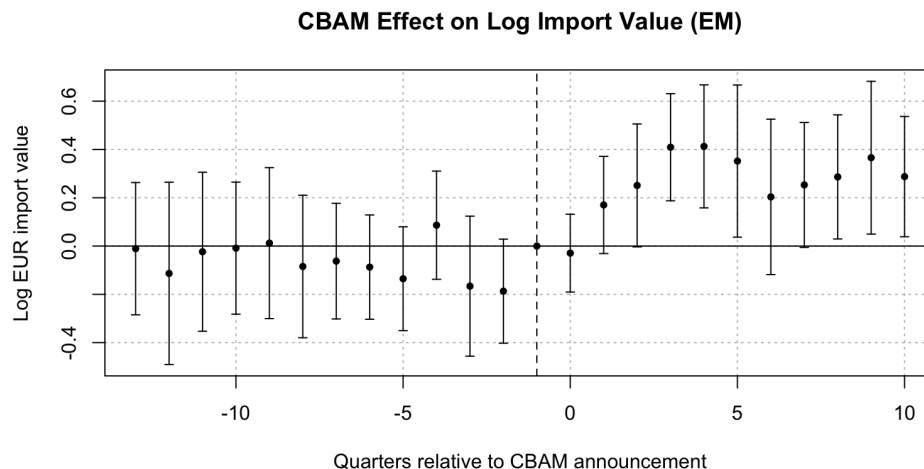


Figure 2. CBAM Effect on Import Values: Emerging Markets

Notes: Event-study coefficients $\hat{\beta}_\tau$ from equation (1) for the emerging market subsample, with 95% confidence intervals. Standard errors clustered at the country level. The omitted reference period is $\tau = -1$.

This interpretation is consistent with the structure of CBAM incentives. Because EU importers will eventually face certificate obligations tied to the carbon intensity of imported goods, importers sourcing from relatively carbon-intensive emerging market

⁶Since the dependent variable is log export value, the percentage effect is recovered as $(e^{\hat{\beta}_\tau} - 1) \times 100$

producers may have incentives to increase purchases before full implementation. For example, EU firms importing steel from India may anticipate higher future CBAM liabilities due to the carbon intensity of coal-based steel production, encouraging earlier procurement. Similar incentives may apply to imports of aluminium and steel from China, where production remains relatively emissions-intensive. Even among trading partners more integrated into EU supply chains, such as Turkey, importers may still have incentives to frontload purchases, although potentially to a lesser extent due to comparatively lower expected compliance costs.

5.2 Advanced Economies

Figure 3 plots the corresponding estimates for advanced economies. The pre-announcement coefficients are largely indistinguishable from zero, supporting the parallel trends assumption for this subsample. Post-announcement coefficients are positive but statistically insignificant throughout, providing no evidence of frontloading behaviour. This contrast with the emerging market results suggests that the frontloading response is concentrated among emerging market exporters, consistent with these countries facing greater uncertainty about their future compliance costs under CBAM.

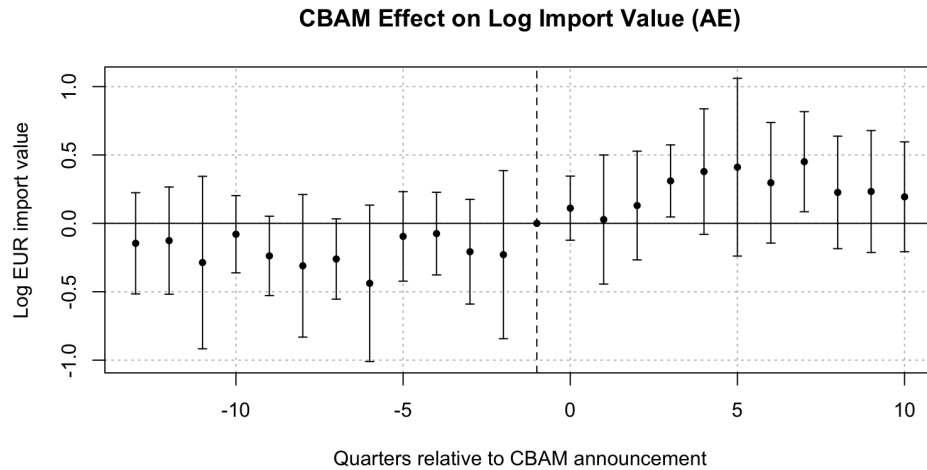


Figure 3. CBAM Effect on Import Values: Advanced Economies

Notes: Event-study coefficients $\hat{\beta}_\tau$ from equation (1) for the advanced economy subsample, with 95% confidence intervals. Standard errors clustered at the country level. The omitted reference period is $\tau = -1$.

One possible explanation is that imports from advanced economies are generally associated with lower carbon intensity, stronger emissions reporting systems, and in some cases existing domestic carbon pricing mechanisms. As a result, EU importers may expect lower effective CBAM liabilities and fewer compliance frictions when sourcing from advanced economies, reducing the incentive to accelerate purchases prior to implementation.

6 Policy Implications

The findings carry several implications for the design of climate-linked trade policy, particularly for developing economies facing the prospect of significant adjustment costs under CBAM.

First, the results suggest that phased implementation schedules can generate intertemporal distortions in trade flows. Because CBAM obligations were announced well before financial enforcement begins, firms and importers appear to have adjusted behaviour in advance by accelerating purchases of CBAM-covered goods. Policymakers designing future climate-linked trade measures should therefore account not only for long-run compliance effects, but also for short-run anticipatory responses that may temporarily reshape trade patterns.

Second, strengthening MRV capacity in developing economies could significantly ease the compliance burden. Because EU importers must declare the embedded emissions of imported goods, exporters that can provide reliable and verifiable emissions data are better positioned to maintain market access, and international support for building such capacity in emerging markets may therefore be critical in easing the transition.

Third, domestic carbon pricing offers a direct route to reducing effective CBAM liabilities. Since importers may deduct any carbon price already paid in the country of origin, countries that introduce or strengthen domestic carbon pricing mechanisms can offset a significant share of the adjustment burden faced by their exporters at the EU border, while simultaneously creating domestic incentives for green structural transformation.

Finally, access to green finance matters particularly for smaller producers. MSMEs in carbon-intensive sectors may lack the capital to invest in cleaner production processes or to meet CBAM's reporting requirements, and targeted financial support could

be critical in allowing them to remain competitive in the EU market as certificate obligations become financially binding.

7 Conclusion

This paper examines whether the EU’s CBAM generated anticipatory trade responses prior to its formal implementation. Using quarterly bilateral trade data from EU COMEXT between 2018 and 2023, we estimate an event-study specification comparing CBAM-covered sectors to non-covered sectors across advanced and emerging market exporters.

We find evidence that the announcement of CBAM itself altered trade patterns well before certificate obligations became financially binding. In particular, emerging market exporters experienced a significant increase in exports in CBAM-covered sectors relative to non-covered sectors following the July 2021 proposal, consistent with frontloading behaviour by EU importers anticipating future compliance costs. By contrast, we find no statistically significant response among advanced economies.

These findings suggest that climate-linked trade policy can affect international trade flows not only through direct price effects after implementation, but also through expectations and anticipatory adjustment. The results therefore highlight the importance of policy credibility and announcement effects in shaping global trade behaviour. More broadly, the paper contributes to the emerging empirical literature on CBAM by providing evidence that firms and importers respond strategically even during the pre-enforcement phase of environmental regulation.

At the same time, several limitations remain. The analysis focuses on aggregate trade flows and cannot directly identify firm-level mechanisms underlying the observed frontloading response. Future research could examine heterogeneity across firms, products, and emission intensities, as well as investigate whether these anticipatory effects persist after the transition period and full implementation of CBAM in 2026.

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Appendix

A CBAM Certificate Formula

$$\Delta_{\text{CBAM}} = \left[\left(EF_{\text{direct}} + EF_{\text{indirect}} \right)_{\text{import}} - \left(EF_{\text{EU}} \times \phi_t \right) \right] \times \left(P_{\text{EU-ETS}} - P_{\text{export-ETS}} \right)$$

where $t \in \{2026, \dots, 2034\}$

Table 1 defines the key variables entering the CBAM certificate calculation.

Table 1. CBAM Adjustment Formula: Variable Definitions

Variable	Description
Δ_{CBAM}	CBAM certificate liability
EF_{direct}	Scope 1 emissions from production
EF_{indirect}	Scope 2 emissions from electricity use
EF_{EU}	EU benchmark emission factor
ϕ_t	Phase-in factor: share of EU free allocation withdrawn in year t; $\phi_t \in [0, 1]$
$P_{\text{EU-ETS}}$	EU ETS carbon price
$P_{\text{export-ETS}}$	Carbon price paid in origin country