CARBON BORDER ADJUSTMENT MECHANISM AND VIETNAM'S EXPORTS: EVIDENCE FROM A MARKET-LEVEL EVENT-STUDY DESIGN

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Abstract: ***As climate policy increasingly intersects with international trade, carbon border measures such as the European Union's Carbon Border Adjustment Mechanism (CBAM) may reshape export patterns in developing economies. This paper provides one of the first empirical assessments of CBAM using monthly HS6-level trade data for Vietnam. Exploiting the introduction of CBAM's transitional phase in October 2023, a difference-in-differences event-study design is employed to compare exports to the EU with those to the United States. An interrupted time series model is used as a robustness check. The results indicate a significant and persistent decline in export volumes to the EU following CBAM implementation, with no evidence of pre-trend differences. The findings highlight the growing impact of green trade barriers and the challenges they pose for developing exporters.***

• Keywords: *carbon border adjustment mechanism; international trade and environment; exports; carbon regulation; Vietnam.*

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1. Introduction

In recent years, climate policy has increasingly reshaped the architecture of international trade. As economies commit to decarbonization under the Paris Agreement, trade instruments are being adapted to address carbon leakage and competitive distortions. Among these, the European Union's Carbon Border Adjustment Mechanism (CBAM) represents a major attempt to integrate carbon pricing into cross-border trade. Introduced under the European Green Deal, CBAM requires imports to bear a carbon cost equivalent to that faced by EU producers, thereby preserving environmental integrity while limiting relocation of carbon-intensive production (European Commission, 2021).

Unlike traditional tariffs, CBAM links market access to embedded emissions and imposes detailed reporting requirements on foreign exporters. Although its transitional phase began in October 2023 without financial obligations, anticipated compliance costs and regulatory uncertainty may already influence trade behavior. These features make CBAM a distinct form of trade friction, particularly for exporters from developing economies with limited capacity for emissions monitoring.

For export-oriented countries such as Vietnam, these challenges are substantial. The EU is one of Vietnam's largest trading partners, with bilateral trade reaching approximately USD 73 billion in 2025 (General Department of Vietnam Customs, 2025). However, several key export sectors, such as iron and steel, cement, aluminum, and fertilizers, fall directly within the scope of CBAM. These industries are energy-intensive and exhibit heterogeneous environmental performance, raising concerns about compliance costs and competitiveness. Figure 1 presents the trend in Vietnam's export quantities to the EU for CBAM-covered products from 2018 to mid-2025. The descriptive evidence suggests noticeable adjustments following the introduction of the transitional phase. While financial obligations were not yet imposed, the policy shift may have altered expectations and

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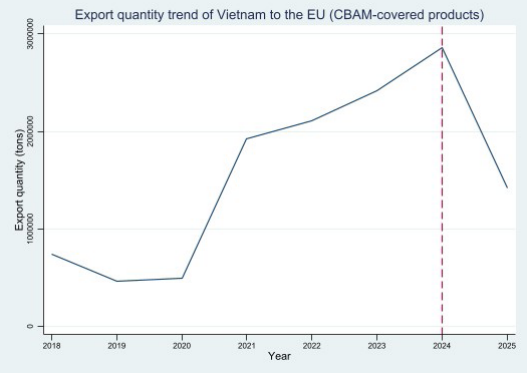
export dynamics, motivating a rigorous empirical assessment.

Existing studies on CBAM are largely theoretical or simulation-based, often relying on computable general equilibrium models (Bellora & Fontagné, 2023). Empirical evidence based on realized trade data remains limited, particularly for developing countries. Building on the theoretical arguments and empirical gaps discussed above, this study examines not only whether CBAM affects Vietnam's exports, but also how such effects vary across markets and evolve over time. In particular, the analysis investigates whether the implementation of CBAM is associated with a decline in export quantities of covered products to the EU, relative to a comparable non-CBAM market. By exploiting variation across destinations and over time, the study further assesses whether the impact of CBAM reflects its market-specific policy nature and whether export responses exhibit dynamic adjustment patterns around the introduction of the transitional phase in October 2023. This framework enables a comprehensive evaluation of both the magnitude and the temporal evolution of CBAM-induced trade effects.

Figure 1. Export Quantity of Vietnam's CBAM-Covered Products to the EU, 2018-2025



Source: Authors' calculations based on UN Comtrade data

2. Literature Review

In recent decades, trade policy instruments implemented by importing countries have played an increasingly important role in shaping international trade flows. A large body of literature shows that tariffs, non-tariff barriers, and technical regulations increase trade costs, restrict market access, and reduce export competitiveness (Bernal, Cummins, & Gasparrini, 2017). These policy changes are often treated as quasi-exogenous shocks, making them suitable for causal identification using difference-in-differences and event-study approaches.

With the growing urgency of climate change, environmental policies have emerged as a new form of trade-related regulation. Carbon taxes, emissions trading systems (ETS), and environmental standards imposed by importing countries can increase production and compliance costs for exporters, particularly in carbon-intensive industries such as steel, cement, and fertilizers. While the Porter hypothesis suggests that environmental regulation may enhance long-run competitiveness through innovation (Porter & van der Linde, 1995), empirical evidence typically points to short-run competitiveness losses, especially for developing countries (Aichele & Felbermayr, 2015).

Importantly, most existing studies focus on domestic environmental regulations rather than border adjustment mechanisms. In contrast, border carbon measures operate directly through trade channels by imposing carbon-related costs on imports. The CBAM represents the most prominent example of such a policy. Introduced under the European Green Deal, CBAM aims to prevent carbon leakage by aligning the carbon cost of imports with the EU's internal carbon pricing system. Although its transitional phase, starting in October 2023, focuses on emissions reporting rather than financial obligations, it may already generate trade frictions due to compliance requirements and regulatory uncertainty. Furthermore, the existing literature on CBAM is largely based on simulation methods, particularly computable general equilibrium (CGE) models. These studies generally predict negative impacts on exports from carbon-intensive economies and highlight potential shifts in global trade patterns (Bellora & Fontagné, 2023). However, such analyses rely on strong assumptions and do not capture actual trade responses. Empirical evidence based on observed trade data remains limited, especially for developing countries.

3. Research methodology and model

3.1. Research methodology

This study adopts a quasi-experimental difference-in-differences (DID) design to identify the causal impact of CBAM on Vietnam's exports (Bertrand et al., 2004). The identification exploits cross-market variation, with the EU as the treated market following CBAM implementation in October 2023 and the United States as the control market. At the first step, a monthly HS6-level panel dataset is constructed to capture product-market variation over time. At the second step, a DID model is estimated and extended into a dynamic event-study specification to test the parallel trends assumption and trace the evolution of export responses (Autor, 2003). At the final step, an Interrupted Time Series (ITS) model on EU-only data (Bernal et al., 2017) is implemented to detect structural breaks at the policy threshold. This multi-step strategy strengthens causal inference and mitigates concerns about confounding global shocks.

3.2. Empirical model

To quantify the impact of CBAM on Vietnam's exports, we estimate the following event-study DID specification:

$$ln(Y_{pmt}) = \alpha_{pm} + \delta_t + \sum_{k \neq -1} \beta_k \left[1\{relt_t = k\} \times CBAM_p \times EU_m\right] + \varepsilon_{pmt}$$

where Y_{pmt} denotes export quantity of product ppp to market mmm in month ttt.

In the baseline specification, the primary dependent variable is the natural logarithm of export quantity:

$$\ln_qty = \ln(1 + quantity_kg)$$

The logarithmic transformation mitigates the influence of extreme values and preserves zero trade observations, which are non-negligible in high-frequency product-level trade data. The variable $CBAM_p$ identifies products covered under the CBAM regulation, and EU_m indicates the treated market. The variable $relt_t$ measures the number of months relative to October 2023, with k = -1 omitted as the reference category. The model includes productmarket fixed effects α_pm, which absorb all time-invariant comparative advantage patterns across product-destination pairs. Monthly fixed effects δ_t control for global trade shocks common to all markets. Standard errors are clustered at the HS6-product level to account for serial correlation and heteroskedasticity within product-level export flows. The coefficients β_k represent dynamic treatment effects. Pre-treatment coefficients ($k<0$) serve as a diagnostic test of the identifying assumption. Post-treatment coefficients ($k\geq0$) capture the magnitude and persistence of export adjustments following CBAM implementation.

To complement the baseline model, we estimate the following Interrupted Time Series specification using EU-only data:

$$ln(Y_{pt}) = \alpha_p + \theta_{moy} + \beta_1 Post_t + \beta_2 Trend_t + \beta_3 (Post_t \times Trend_t) + u_{pt}$$

where $Post_t$ equals one from October 2023 onward, and $Trend_t$ captures linear time dynamics. Product fixed effects α_p absorb time-invariant heterogeneity, while seasonal fixed effects θ_{moy} account for intra-year trade seasonality. The coefficient β_1 measures the immediate level shift at the time of CBAM introduction, and β_3 captures changes in export growth trajectories after policy implementation.

4. Data and descriptive statistics

This study employs monthly bilateral trade data at the HS6 × destination × month level to examine the impact of CBAM on Vietnam's exports. The sample spans multiple years before and after the introduction of CBAM's transitional phase in October 2023, providing sufficient pre- and post-policy observations for dynamic analysis. Trade data are sourced from the European Commission's Comext database and UN Comtrade, which provide detailed information on export quantities and values by HS6 product and destination. The sample is restricted to CBAM-covered products, including sectors such as iron and steel, aluminum, cement, and fertilizers. Observations are constructed at the product-market-month level for two destinations: the European Union (EU) and the United States (US). The EU is defined as the treated market, while the US serves as a control market, as it does not implement a comparable border carbon adjustment mechanism during the study period. This cross-market structure enables identification of CBAM-specific effects while controlling for

common global trade shocks. Export quantities are measured in kilograms, and the final dataset contains approximately 10,500 product-market-month observations after standard data cleaning procedures. Observations with missing values are excluded, and HS6 product codes are harmonized to ensure consistency over time. The resulting panel dataset exhibits substantial cross-product heterogeneity and temporal variation, providing a suitable empirical setting to identify the causal impact of CBAM on Vietnam's exports.

Table 1 reports summary statistics for the main variables, showing a balanced sample of approximately 10,500 product-market-month observations with substantial cross-product and temporal variation. The dataset exhibits sufficient pre- and post-treatment coverage and variability to support reliable identification in the event-study DID framework.

Table 1. Descriptive Statistics

Variable	Obs	Mean	Std.Dev	Min	Max
ln_{qty}	10,513	8.868	5.502	0.000	22.411
$quantity_{kg}$	10,513	4,511,677	74,400,000	0.000	5,410,000,000
EU	10,551	0.509	0.500	0.000	1.000
Post	10,551	0.242	0.428	0.000	1.000
treated	10,551	0.509	0.500	0.000	1.00p0
relt	10,551	-24.000	26.269	-69.000	21.000
$Post_{take}$	10,551	0.374	0.484	0.000	1.000
CBAM	10,551	1.000	0.000	1.000	1.000

Source: Calculations by the authors

5. Results

5.1. Event-study evidence

Table 2 reports the dynamic Difference-in-Differences (event-study) estimates, where the dependent variable is the logarithm of export quantity. The coefficients capture the relative change in Vietnam's CBAM-covered exports to the EU compared to the US, at different months around the policy's transitional implementation (October 2023).

The post-policy coefficients ($k \geq 0$) are consistently negative and statistically significant. At the implementation month ($k = 0$), export quantity declines by approximately 2.53 log points ($p = 0.003$). The magnitude remains economically large and statistically significant in the subsequent months, including $k = 1$ (-2.68, $p = 0.001$), $k = 2$ (-1.64, $p = 0.041$), $k = 3$ (-2.71, $p = 0.001$), $k = 6$ (-1.93, $p = 0.003$), $k = 12$ (-2.04, $p = 0.007$), and $k = 18$ (-2.09, $p = 0.013$).

These estimates indicate a substantial and persistent relative contraction in export volumes to the EU following the introduction of CBAM. Importantly, the graphical representation in Figure 2 shows that pre-treatment coefficients ($k < 0$) fluctuate around zero and are statistically insignificant, supporting the parallel trends assumption underlying the DID framework. After $k = 0$, the coefficients shift sharply downward and remain negative, suggesting that CBAM is associated with a sustained deterioration in Vietnam's export performance to the EU relative to the control market.

Overall, the event-study results provide strong causal evidence that the transitional phase of CBAM coincides with a significant and economically meaningful decline in export quantities of affected products.

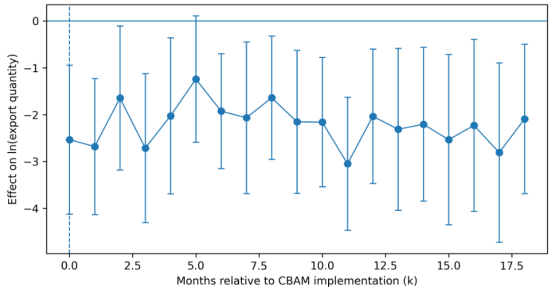
Table 2. Event-Study Estimates: Impact of CBAM on Export Quantity

Event time (k)	Coefficient	Standard Error (SE)	p
k=0	-2.532	(0.811)	0.003
k=1	-2.682	(0.741)	0.001
k=2	-1.644	(0.785)	0.041
k=3	-2.714	(0.812)	0.001
k=6	-1.925	(0.626)	0.003
k=12	-2.035	(0.732)	0.007
k=18	-2.091	(0.815)	0.013

Source: Calculations by the authors

To complement the regression results, Figure 2 visualizes the dynamic treatment effects by plotting event-time coefficients and their 95% confidence intervals from the baseline specification. First, the pre-treatment coefficients ($k < 0$) are centered around zero and statistically insignificant, providing visual support for the parallel trends assumption and indicating no pre-policy divergence between the EU and US markets. Second, starting at $k = 0$, the coefficients shift downward and remain negative throughout the post-treatment period, suggesting a persistent and economically meaningful decline in exports rather than a temporary adjustment. Third, the structural break aligns closely with the timing of CBAM implementation, with no evidence of gradual pre-trends, reinforcing the interpretation that the observed effects are attributable to the policy rather than to external shocks.

Figure 2. Event-study estimates of the impact of CBAM on Vietnam's exports (EU relative to US)



Notes: The figure plots the estimated event-time coefficients (β_k) from the difference-in-differences event-study specification. The omitted category is k = −1 (the month prior to CBAM implementation in October 2023). Vertical bars represent 95% confidence intervals. Standard errors are clustered at the HS6-product level.

Source: Authors' estimates based on UN Comtrade data.

5.2. Robustness Check: Interrupted Time Series (EU-only)

To assess robustness, Table 3 reports Interrupted Time Series (ITS) estimates using EU-only data for CBAM-covered products, testing for a structural break at the policy cutoff (October 2023).

Prior to CBAM, exports exhibit a positive and statistically significant trend for both value and quantity, indicating steady growth in shipments to the EU. The level-shift coefficient (post) is positive and significant, suggesting no immediate collapse in exports at the implementation date.

However, the interaction term between the post period and the time trend (t_post) is negative and statistically significant, indicating a marked slowdown in export growth after CBAM's introduction. This pattern implies that the policy is associated with a deterioration in the growth trajectory rather than an abrupt level shock.

The magnitude of the slope change is somewhat larger for export value than for quantity, suggesting that firms may initially adjust through pricing or product composition before fully responding in terms of volumes.

Overall, the ITS results are consistent with the event-study findings. While the DID estimates capture a relative decline in exports to the EU compared to the US, the ITS analysis confirms a structural break in the underlying export trajectory. Together, these results strengthen the conclusion that CBAM is associated with a meaningful slowdown in Vietnam's exports to the EU during its transitional phase.

Table 3. Interrupted Time Series (ITS) Estimates for EU Exports

Variables	(1) ln_val	(2) ln_qty
Post	4.013**	2.998*
	(1.650)	(1.579)
t	0.035***	0.024***
	(0.007)	(0.007)
t × Post	−0.056**	−0.039*
	(0.022)	(0.021)
Observations	5,334	5,331

Notes: Robust standard errors in parentheses.
*$p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.*

5.3. Discussions

The empirical results provide consistent evidence that the European Union's Carbon Border Adjustment Mechanism (CBAM) is associated with a statistically significant decline in Vietnam's exports of covered products to the EU relative to the control market. The event-study estimates show that negative effects emerge immediately after October 2023 and persist over time, suggesting that CBAM operates as a trade-relevant policy shock rather than purely an environmental measure. This finding aligns with simulation-based studies, such as Do (2025), while extending them by providing causal evidence based on observed trade data.

Second, the absence of significant pre-treatment coefficients supports the parallel trends assumption, reinforcing the validity of the identification strategy (Bertrand et al., 2004). The clear structural break at the policy implementation date and the sustained divergence thereafter indicate that the observed decline is unlikely to be driven by common global shocks.

Third, the dynamic pattern suggests that the impact of CBAM is persistent rather than transitory. The continued negative effects imply structural adjustment costs for exporters, consistent with the literature on carbon-related trade measures (Bellora & Fontagné, 2023). The ITS results further confirm that while no immediate collapse occurs, the post-CBAM growth trajectory weakens significantly.

Fourth, the presence of negative effects during the transitional phase points to anticipatory behavior. Firms may adjust shipments and

contracts in response to reporting requirements and expected future costs, even before full financial obligations are enforced.

Finally, the magnitude of the decline supports the view that CBAM may disproportionately affect developing economies, where firms face higher compliance costs and limited access to green technologies (UNCTAD, 2021). Overall, the findings highlight the early and persistent trade impacts of emerging green trade barriers.

6. Conclusion and Policy Implications

This study investigates the impact of the EU's Carbon Border Adjustment Mechanism (CBAM) on Vietnam's exports of covered products using monthly HS6-level bilateral trade data and a quasi-experimental identification strategy. By combining an event-study Difference-in-Differences framework with an Interrupted Time Series robustness design, the paper aims to provide causal and dynamic evidence on how CBAM has affected export performance during its transitional phase. The empirical results consistently indicate that CBAM is associated with a statistically significant and persistent decline in Vietnam's export volumes to the EU. The negative effects emerge immediately after October 2023 and remain stable over time, suggesting that CBAM functions as a trade-relevant policy shock rather than a purely environmental regulation. The ITS results further show that while no abrupt collapse occurs at the policy threshold, the post-CBAM growth trajectory weakens significantly, implying a structural slowdown in export dynamics. Together, these findings highlight that even during the reporting-only transitional phase, CBAM has already reshaped trade patterns.

The findings of this study carry several important policy implications for Vietnam in the context of climate-related trade measures. First, the government should develop a coherent national strategy for CBAM adaptation, integrating trade, industrial, and climate policies. The empirical results show that CBAM already affects export dynamics during the transitional phase, implying that reactive and fragmented responses may be costly. A coordinated roadmap identifying vulnerable sectors, compliance gaps, and phased support mechanisms is therefore essential to mitigate export losses. Second, strengthening domestic carbon measurement, reporting, and verification (MRV) systems is critical. Since CBAM operates through carbon accounting requirements rather than traditional tariffs, compliance capacity becomes a key determinant of competitiveness. Improving technical standards, harmonizing reporting frameworks with EU requirements, and providing centralized guidance, especially for small and medium-sized enterprises, would reduce compliance uncertainty and transaction costs. Third, policy support should move beyond short-term compensation and instead incentivize structural upgrading. Rather than shielding firms from immediate export declines, targeted instruments, such as preferential green finance, carbon-efficient technology subsidies, and export promotion for low-emission products, can facilitate long-term competitiveness in carbon-constrained markets. Fourth, Vietnam should combine adaptation with export diversification. Given that CBAM may gradually reshape global trade patterns, reducing over-reliance on a single market while upgrading product sophistication can enhance resilience against future environmental trade measures.

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