

Estimation of the Impact of the Formal Implementation of the Carbon Border Adjustment Mechanism on the Implicit Carbon Costs of China's Exports and Identification of Trade Transfer Effects

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Abstract. After the EU's Carbon Border Adjustment Mechanism (CBAM) entered the formal stage, the implicit emissions of products began to form the compliance costs at the import stage. This paper examines how this cost affects the destination selection of China's exports. The study calculates the industry costs based on the default path and uses annual panel estimation to estimate the changes in EU exports. In the first year of the formal period, the required clearance ratio is only 2.5%, and the cost is less than 1.5% of the export value to Europe. Under the benchmark setting, the export coefficient to Europe is -0.152, and to the third market is 0.127, with opposite signs. The adjustment term direction also points to market substitution caused by carbon costs. The current expenditure is difficult to explain this combination. The expected quota reduction and compliance preparations are more likely to be the main drivers. Therefore, the assessment of export adjustment must separate the scale compression effect of costs from the order reallocation effect. Research shows that whether or not reliable emission data can be provided is as important as market selection.

Keywords: Carbon Border Adjustment Mechanism, Trade and Environment, Implicit Carbon Cost, Trade Diversion, Carbon Price Gap

1. Introduction

In 2026, the CBAM will be fully implemented, and the covered goods will start to bear the cost of carbon emissions. This mechanism aims to alleviate the competitive distortions caused by differences in carbon pricing among countries, while its actual effects depend not only on institutional design but also on the responses of domestic and foreign stakeholders [1, 2]. For Chinese exporters, the key lies in whether the additional costs can be passed on to the buyers in the EU; if orders are lost and the profits are insufficient to absorb the costs, export diversion will become a realistic choice. Therefore, this paper focuses on the contraction of exports to the EU and whether it is accompanied by the expansion of exports to third countries?

Previous studies have discussed from aspects such as mechanism design [3], policy comparison [4], and the impact on China's high-carbon industries [5], but how carbon emission costs are transformed into trade adjustments at the destination level has not been answered. This paper first calculates the carbon cost using the default emission intensity and assesses the burden on each industry due to the decline in free quotas; then, by using the policy-covered industries as the treatment group and industries with similar carbon intensities as the control group, it identifies the changes in exports. This design incorporates cost calculation and market reallocation into the same framework, allowing the export effects in the EU market to be directly compared with those in the third country market.

2. Theoretical mechanism and research hypotheses

Whether the carbon price paid by a third country can offset the direct change in this gap and thereby affect the burden on importers [6] has not been determined. To ensure consistency, this article only retains the default value path:

$$S_{st} = E_{st}^{def} (1 - F_t), C_{st} = S_{st} P_t^{EU} R_t \quad (1)$$

In Equation (1), E represents the default emission volume, and F is the quota adjustment factor. These two determine the amount of emissions to be cleared, S . P is the certificate price, and R is the exchange rate of the RMB to the euro. The product of S and P , R gives the cost C . The higher the default value, the larger the exposure. Firms can reduce this exposure by submitting recognized actual-emission data when their verified emissions are lower than the applicable default values [7]. At import, the ultimate cost bearer is set by trading partners' bargaining power. Heterogeneous-firm models indicate border carbon adjustments also affect technology adoption, so firm responses differ [8]; those with limited abatement room and thin margins are less able to absorb costs via short-run technical change and are more likely to cut EU exports. Thus H1: *ceteris paribus*, CBAM's new carbon costs reduce EU exports of covered industries. If EU orders fall, redirecting sales to a third market requires local demand to absorb the extra supply; lower entry costs and greater compatibility facilitate this, whereas higher-carbon-cost destinations are less attractive [9, 10]. Thus H2: if the third market meets these conditions, falling EU exports by covered industries coincide with rising exports to that market.

A widening carbon-price differential can strengthen market substitution only insofar as it affects transaction costs. If importers absorb most of the additional burden, Chinese firms have less incentive to reorganize their export destinations; if the burden reduces exporters' net income, their motivation to shift toward other markets increases [11]. The degree of transmission varies across industries and can be approximately measured by the correlation between costs and quotations. Thus, this inference can be tested. Therefore, H3 is proposed: When the costs at other destinations remain unchanged and the aforementioned conditions are met, the higher the degree of carbon cost transmission to export enterprises, the stronger the tendency for exports to shift to the third market.

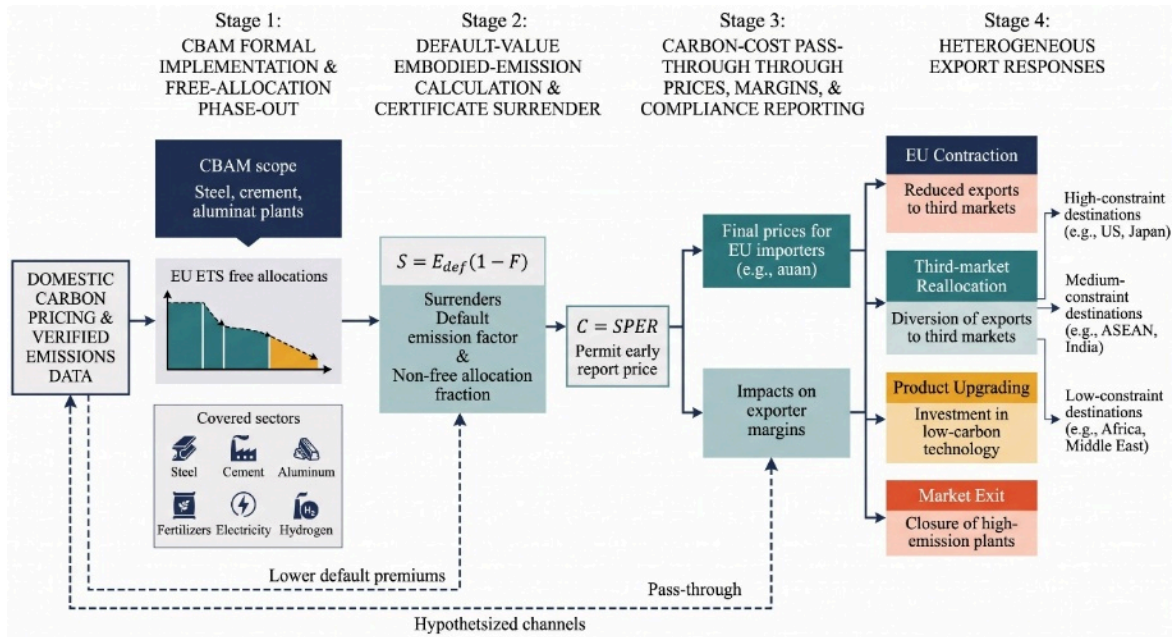


Figure 1. Mechanism diagram

3. Data and research design

The sample period is from 2018 to 2027. 2027 is the extrapolated value. The baseline DID is estimated using the annual industry panel. The event study specification uses monthly trade data. The treatment group consists of six industry categories covered by CBAM, while the control group comes from industries with comparable carbon intensity. The annual model is specified as follows:

$$Y_{st} = \beta (\text{Treat}_s \times \text{Post}_t) + \gamma X_{st} + \mu_s + \lambda_t + \varepsilon_{st} \quad (2)$$

4. Empirical results

Table 1 presents cost estimates for six industries. The default value premiums are not uniform, ranging from 38.7% for cement to 76.1% for steel; the higher premiums of steel and aluminum, which are the two industries with the largest export volumes to Europe, are particularly notable. Aluminum stands out particularly, with the default emission intensity being 74.2% higher than the actual value. The larger the difference between the two numbers, the greater the benefit from submitting actual data, and the choice of accounting path has a substantial impact on the cost exposure of this industry.

Table 1. Cost estimations

Sector	Export value (EUR bn)	Embodied carbon (MtCO ₂ e)	Default intensity (tCO ₂ e/t)	Actual intensity (tCO ₂ e/t)	Default premium (%)	Default-route surrender (MtCO ₂ e)	CBAM cost (RMB bn)	Cost share of export value (%)
Steel	48.6	15.20	3.169	1.80	76.1	0.669	0.393	1.04
Aluminium	31.2	18.70	10.80	6.20	74.2	0.814	0.478	1.96
Cement	2.8	2.10	0.86	0.62	38.7	0.073	0.043	1.97

Table 1. (continued)

Fertiliser	5.1	1.95	2.10	1.35	55.6	0.076	0.045	1.13
Hydrogen	0.3	0.08	14.50	9.80	48.0	0.003	0.002	0.77
Electricity	0.1	0.05	1.20	0.85	41.2	0.002	0.001	1.54
Total	88.1	38.08	—	—	—	1.637	0.962	1.40

Note: the CBAM certificate price is EUR 75.36/tCO₂e; the RMB/EUR exchange rate is 7.8; and the default-route surrender ratio is 2.5%.

Table 1 is based on the clearing ratio in the first year of the formal period, and this ratio is only the starting point for the gradual reduction. Based on this, the medium and long-term burden is likely to be significantly underestimated. Table 2 therefore extends to a dynamic scenario of gradually reducing quotas, depicting the time distribution of the burden.

If the export scale and carbon price remain at the 2026 level, the clearing ratio increases from 2.5% to 100% by 2034, and the cost rises from 962 million yuan to 38.47 billion yuan. This path implies that the initial burden in the formal period does not represent the medium- and long-term constraints, and enterprises' emission reduction investments have intertemporal benefits.

Table 2. Dynamic scenario

Year	Surrender ratio (%)	Default-route emissions (MtCO ₂ e)	Surrendered emissions (MtCO ₂ e)	CBAM cost (RMB bn)	Cost share of export value (%)
2026	2.5	65.45	1.637	0.962	1.40
2030	48.5	65.45	31.74	18.66	27.17
2034	100.0	65.45	65.45	38.47	56.01

As reported in Table 3, the complete specification produces an export coefficient for Europe of -0.152. Applying the transformation $100 \times [\exp(\beta) - 1]$ yields an estimated decline of approximately 14.1%. The coefficient for the third market is 0.127, which corresponds to an increase of approximately 13.5%.

Table 3. Coefficient table

Variable	ln(EU exports)	ln(EU exports)	ln(EU exports)	ln(third-market exports)	ln(third-market exports)	ln(third-market exports)
	(1)	(2)	(3)	(4)	(5)	(6)
DID	-0.187*** (0.042)	-0.164*** (0.038)	-0.152*** (0.035)	0.098** (0.045)	0.112** (0.048)	0.127*** (0.041)
Intensity	—	-0.034** (0.014)	-0.029** (0.012)	—	0.018* (0.010)	0.021** (0.009)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Partner FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Gravity controls	No	No	Yes	No	No	Yes
Observations	4,872	4,872	4,872	5,136	5,136	5,136
R ²	0.382	0.411	0.467	0.156	0.189	0.234

Table 4 shows that the interaction between the cost-transmission rate and exports is negative for Europe but positive for the third market, in line with Hypothesis H3. The interaction involving the carbon-price differential has the same signs. For third-market exports, the interaction coefficient for substitution elasticity is 0.091, suggesting an association between the conditions for market substitution and export adjustments.

Table 4. Cost-transmission rate

Moderating variable	EU exports	Third-market exports	Trade diversion elasticity
	(1)	(2)	(3)
DID × Carbon cost pass-through	−0.089** (0.038)	0.034* (0.019)	0.41*** (0.12)
DID × EU–China carbon price gap	−0.143*** (0.046)	0.067** (0.028)	0.52*** (0.15)
DID × Substitution elasticity	−0.056* (0.031)	0.091*** (0.026)	0.78*** (0.19)
Carbon cost pass-through (main effect)	—	—	0.34** (0.14)
Controls and fixed effects	Yes	Yes	Yes
Observations	4,872	5,136	4,872
R ²	0.512	0.298	0.445

5. Dynamic effects, robustness and heterogeneity

None of the pre-policy coefficients reported in Table 5 attained conventional statistical significance. The p-value of the joint test was 0.2157, providing no clear evidence of a pre-policy differential trend. The four coefficients for the individual post-policy periods were likewise statistically insignificant.

Table 5. Dynamic Effects

Relative period kk	Coefficient	Std. error	p-value	95% CI
−5	−0.012	0.041	0.770	[−0.092, 0.068]
−4	0.008	0.039	0.837	[−0.068, 0.084]
−3	−0.021	0.037	0.571	[−0.094, 0.052]
−2	0.015	0.035	0.668	[−0.054, 0.084]
−1	−0.036	0.034	0.280	[−0.103, 0.030]
1	−0.021	0.036	0.560	[−0.092, 0.050]
2	−0.013	0.038	0.732	[−0.087, 0.061]
3	−0.013	0.040	0.745	[−0.091, 0.065]
4	−0.008	0.042	0.849	[−0.090, 0.074]
Joint pre-test	—	—	0.2157	—
Cumulative post effect	−4.706	0.657	<0.001	—

Table 6 shows that in 2021, the time placebo coefficient was -0.031 and was not significant. The mean value of the spatial placebo was close to zero, and the baseline coefficient was in the left tail of the random distribution, indicating that the main result is unlikely to be generated by any industry marker.

Table 6. Placebo tests

Test	Statistic	Value	Std. error / SD	p-value / percentile
Time placebo (2021)	DID coefficient	-0.031	0.038	0.412
Spatial placebo (500 draws)	Mean DID coefficient	-0.004	0.038	—
Spatial placebo (500 draws)	Baseline estimate	-0.152	—	<95% percentile
Spatial placebo (500 draws)	Baseline rank	—	—	Far left tail

Table 7 summarizes the alternative estimates. The coefficients of PPML, Sun–Abraham interaction-weighted estimation, wild cluster bootstrap method, excluding the years with epidemics, PSM-DID, and IV-2SLS all remain negative, with the range approximately -0.138 to -0.178. The IV-2SLS coefficient is slightly larger than the baseline value, combined with the F value of the first stage of 28.7, suggesting that the carbon pricing coverage instrument variable is correlated.

Table 7. Robustness summary

Dimension	Strategy	DID coefficient	Std. error	Significance	Difference from baseline
Baseline	Two-way fixed-effects OLS	-0.152	0.035	1%	—
Parallel trend	Joint pre-test	—	—	p=0.216 p=0.216	Not rejected
	Excluding k=-1k=-1	-0.167	0.037	1%	-9.9%
Placebo	Time placebo (2021)	-0.031	0.038	Not significant	—
	Spatial placebo (500 draws)	-0.004	0.038	Not significant	—
Estimation	PPML	-0.178	0.042	1%	+17.1%
	Sun–Abraham IW	-0.149	0.038	1%	-2.0%
	Wild cluster bootstrap	-0.152	0.041	5%	0.0%
Sample	Excluding pandemic years	-0.144	0.034	1%	-5.3%
	Extended time window	-0.138	0.036	5%	-9.2%
	Export volume instead of value	-0.163	0.039	1%	+7.2%
Endogeneity	PSM-DID (kernel matching)	-0.159	0.037	1%	+4.6%
	PSM-DID (nearest-neighbour matching)	-0.154	0.036	1%	+1.3%
	IV-2SLS	-0.171	0.040	1%	+12.5%

6. Conclusion

Market adjustments merely gain time and cannot replace the enterprises' own emission reduction efforts. The shift in the target can alleviate short-term pressure, but it does not change the emission intensity. If a third country introduces a similar mechanism, the same constraints will reappear. Only when actual emissions decline and are included in cost accounting can the emission reduction

investment be reflected as cost savings; if low emissions cannot be recognized, technological improvements will be difficult to turn into a competitive advantage in the short term. Regarding China's response to CBAM, existing studies have already discussed from the perspective of carbon governance [12]. This paper further proposes that the verification preparation should be incorporated into business decision-making rather than being solely the responsibility of the compliance department. The expansion to the third market itself does not constitute a systemic cost that has been absorbed. The policies of the destination country are also changing. The applicability of the above conclusions depends on two limitations. The end year of the sample, 2027, is an estimated figure, and the short-term fluctuations in emissions cannot fully reflect the situation. Relaxing restrictions requires more detailed underlying data. If subsequent research can introduce verified emission records at the enterprise level and micro transaction data, it will be possible to connect cost calculation and destination adjustment over a shorter time lag.

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