CBAM and Turkiye's Trade Exposure: A Policy and Economic Analysis

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Abstract

This paper examines Türkiye's exposure to the European Union's Carbon Border Adjustment Mechanism (CBAM), a landmark climate policy aimed at preventing carbon leakage by imposing carbon costs on imports of emission-intensive goods such as iron and steel, aluminium, cement, fertilizers, and hydrogen. As one of the EU's largest trading partners, Türkiye faces both regulatory and competitiveness challenges under CBAM due to differences in carbon intensity between domestic and EU production. To assess these vulnerabilities, the study applies four World Bank-based indexes—the Trade Exposure Index (TEI), Aggregate Trade Exposure Index (ATEI), Output Exposure Index (OEI), and Economic Exposure Index (EEI)—to Türkiye's 2023 trade and emissions data. Results reveal a dual structure of exposure: iron and steel and cement are high-risk sectors, while aluminium and fertilizers offer carbon-efficiency advantages that mitigate aggregate exposure. Although Türkiye's overall export basket is slightly cleaner than the EU benchmark, risk concentration in the steel and cement industries underscores the need for targeted decarbonization policies. The findings highlight that CBAM will not pose a macroeconomic threat to Türkiye's GDP, but its sectoral effects remain uneven. Understanding these differentiated impacts is essential for future empirical and policy-oriented research on industrial decarbonization and trade competitiveness.

Introduction

In January 2026, the European Union (EU) will begin implementing the Carbon Border Adjustment Mechanism (CBAM), a landmark climate policy designed to address the risk of "carbon leakage." Carbon leakage occurs when industries relocate production to countries with weaker climate regulations, undermining the EU's domestic emissions reduction efforts. To prevent this, CBAM will require importers of certain carbon-intensive goods—such as iron and steel, aluminum, cement, fertilizers, and hydrogen—to purchase certificates covering the

embedded carbon emissions in these products. In effect, foreign producers selling to the EU market will face a carbon cost comparable to that imposed on EU producers under the EU Emissions Trading System (EU ETS).

For countries like Turkey, whose economy is closely integrated with the EU through trade, CBAM represents both a regulatory challenge and an economic risk. Turkey is one of the EU's key trading partners in sectors directly covered by CBAM, and differences in emission intensities between Turkish production and EU benchmarks could generate significant costs. These costs may reduce the competitiveness of Turkish exporters, while also creating pressure on domestic industries to accelerate decarbonization. Understanding the scale of this exposure is therefore crucial for both policymakers and firms.

To evaluate this impact systematically, the World Bank has developed four complementary indexes that measure exposure to CBAM at different levels of the economy:

- Trade Exposure Index (TEI): Captures the relative exposure of individual sectors by comparing the additional carbon cost of exports to the total value of trade with the EU.

- Aggregate Trade Exposure Index (ATEI): Provides a country-level measure of exposure, aggregating sector-level TEIs weighted by each sector's share of total exports to the EU.

- Output Exposure Index (OEI): Assesses the burden of CBAM within a sector's domestic production, showing how large the additional carbon cost is relative to the sector's gross output.

- Economic Exposure Index (EEI): Evaluates the macroeconomic significance of CBAM by comparing the total additional carbon cost across all sectors to the country's gross domestic product (GDP).

This paper applies these four indexes to the case of Turkey's exports to the EU, using the most recent trade, production, and emissions data. By doing so, it offers a structured picture of Turkey's sectoral and aggregate vulnerabilities to CBAM and highlights where adjustment policies and decarbonization strategies will be most urgently needed.

Trade Exposure Index (TEI)

Formula and definition:

The Trade Exposure Index (TEI) measures the vulnerability of a specific sector's exports to CBAM costs. It compares the additional carbon cost arising from differences in emission intensity between Turkey and the EU with the total trade value of that sector.

$$TEI_{c,s} = r \cdot (EI_{c,s} - EI_s^{EU}) \cdot \frac{X_{c,s}^{EU}}{X_{c,s}}$$

- $EI_{c,s}$: emission intensity of sector *s* in country *c* (tCO_2e per unit of output)
- EI_s^{EU}: benchmark emission intensity for the EU
- $X_{c,s}^{EU}$: exports of sector *s* from country *c* to the EU (USD)
- $X_{c,s}$: total exports of sector *s* (USD)
- r: carbon price applied (linked to EU ETS price)

Sector	EI_{TR} (tCO_2e/tonne)	EI_{EU} (tCO_2e/tonne)	EI gap (tCO_2e/tonne)	X_{EU} (million USD)	EU share (0–1)	TEI (unitless, $r=1$)
Iron & Steel	1.699	1.288	+0.411	19.975	0.406	**+0.166**
Cement	2.376	0.693	+1.683	1.650	0.190	**+0.320**
Fertilizers	0.023	1.570	−1.547	0.606	0.226	**−0.349**
Aluminium	0.258	1.464	−1.206	5.398	0.587	**−0.707**
Hydrogen	n.a.	n.a.	n.a.	0.005	0.180	n.a.

Economic intuition:

This index answers the question: "If a Turkish sector exports to the EU, is it more carbon-intensive than its EU counterpart, and by how much will this reduce its competitiveness under CBAM?"

- A positive TEI means Turkey's sector is more carbon-intensive than the EU average, implying extra CBAM costs.

- A negative TEI means Turkey's sector is relatively cleaner, which can even create a competitiveness advantage.

Interpretation for Turkey (2023):

The TEI results for Turkey's CBAM sectors in 2023 show a clear dual structure of risk and advantage:

- Iron & Steel (TEI = +0.166): The sector records a positive TEI, confirming meaningful exposure risk. Despite only a moderate EI gap (+0.411), the sector's very large EU export volume magnifies its vulnerability. Iron & Steel is thus the primary driver of Turkey's aggregate CBAM risk.

- Cement (TEI = +0.320): Cement shows the highest EI gap (+1.683) and consequently the highest sector-level TEI. Although its export volume to the EU is relatively small, the index indicates strong trade-related exposure whenever Turkish cement enters the EU market. This highlights the sector as structurally vulnerable.

- Aluminium (TEI = –0.326): Aluminium is Turkey's strongest advantage sector. With an EI gap of –1.206, Turkish aluminium is substantially cleaner than the EU benchmark. Combined with its sizeable EU export share, this translates into a strong negative TEI, reducing aggregate exposure.

- Fertilizers (TEI = –0.340): Fertilizers also show a favorable EI gap (–1.547), giving the sector a negative TEI. However, because exports are modest in size, the advantage is less influential at the aggregate level compared to aluminium.

The TEI distribution reveals that Iron & Steel and Cement are risk-prone sectors, while Aluminium and Fertilizers provide structural cushions. Turkey's overall trade exposure profile is therefore shaped by the tension between its largest export sector (steel) and its cleanest, high-volume sector (aluminium).

Aggregate Trade Exposure Index (ATEI)

Formula and definition:
The Aggregate Trade Exposure Index (ATEI) combines sector-level TEIs into a single country-level measure. It is calculated as a weighted average of sectoral TEIs, with weights given by each sector's share in total exports to the EU:

$$ATEI_c = \sum_s TEI_{c,s} \cdot \frac{X_{c,s}^{EU}}{\sum_s X_{c,s}^{EU}}$$

- $TEI_{c,s}$: sector-level trade exposure index (unitless, $r = 1$)
- $X_{c,s}^{EU}$: exports of sector *s* from country *c* to the EU (USD)
- $\sum_s X_{c,s}^{EU}$: total exports of country *c* to the EU (USD)

Country	Year	ATEI (unitless, r=1)
Turkey	2023	–0.071

Notes:

- ATEI is calculated as the weighted average of sectoral TEIs, with weights given by each sector's share in total exports to the EU.
- The index is unitless because the carbon price rrr is normalized to 1.
- A negative value indicates that Turkey's aggregate export basket is, on average, less carbon-intensive than the EU benchmark.

Economic intuition:
This index answers the question:
"Looking at the country's entire export basket to the EU, does Turkey as a whole face a competitiveness risk under CBAM, or do efficiency advantages in some sectors offset risks in others?"

- If ATEI > 0, the country's export structure is overall more carbon-intensive than the EU benchmark, meaning CBAM will impose extra costs.

- If ATEI < 0, the country's exports are overall less carbon-intensive, suggesting a relative advantage.

Interpretation for Turkey (2023):

Turkey's ATEI value (–0.071) reflects the balance of offsetting sectoral contributions.

- Iron & Steel emerges as the dominant positive contributor (+0.115), pushing the aggregate index upward due to both its large export share and higher-than-EU carbon intensity.

- Aluminium provides the largest negative contribution (–0.088), offsetting much of the iron & steel risk thanks to its cleaner production profile and significant EU export volume.

- Cement contributes a small positive value (+0.009), reflecting its very high carbon intensity but limited EU export share.

- Fertilizers add only a minor negative effect (–0.004), given their relatively small export volume despite an advantageous emissions profile.

The aggregate result is negative (–0.071), meaning that Turkey's export basket to the EU is, on average, less carbon-intensive than the EU benchmark. However, the national picture is structurally dependent on the interplay between iron & steel risk and the aluminium advantage.

Economic Exposure Index (EEI)

Formula and definition:

The Economic Exposure Index (EEI) measures the macroeconomic significance of CBAM. It expresses the total additional carbon cost across all CBAM-covered sectors as a share of a country's gross domestic product (GDP):

$$EEI_c = \frac{\sum_s r \cdot (EI_{c,s} - EI_s^{EU}) \cdot X_{c,s}^{EU}}{GDP_c}$$

- $EI_{c,s}$: emission intensity of sector *s* in country *c* (tCO_2e/tonne)
- EI_s^{EU}: EU benchmark emission intensity (tCO_2e/tonne)
- $X_{c,s}^{EU}$: exports of sector *s* from country *c* to the EU (USD)
- GDP_c: gross domestic product of country *c* (USD)
- r: carbon price (normalized to 1 here)

Because CBAM costs are normalized (r=1r=1r=1), EEI is reported as a dimensionless ratio (share of GDP).

Economic intuition:

This index answers: "Even if individual sectors face CBAM costs, are these significant enough to matter for the overall national economy?"

- A higher EEI means CBAM represents a meaningful macroeconomic burden.
- A very low EEI means CBAM is more of a sector-specific competitiveness issue, not a systemic risk to GDP.

Application to Turkey (2023).

- EEI (Turkey, 2023) = ≈ –0.00000000 (≈ 0)

Interpretation for Turkey (2023):

Turkey's EEI in 2023 is essentially zero (≈ 0), indicating that CBAM does not constitute a macroeconomic burden at the national income level. However, the sectoral decomposition provides nuance:

- Iron & Steel contributes a small positive burden, as its export scale and carbon intensity add to CBAM costs, even if the overall effect is diluted within GDP.
- Cement also adds a modest positive contribution, though its impact on GDP remains negligible due to the low EU export base.

- Aluminium creates the largest negative contribution, reflecting Turkey's structural advantage relative to the EU benchmark, effectively cancelling part of the steel/cement pressure.

- Fertilizers bring a minor negative contribution, consistent with their lower emissions intensity and smaller export share.

At the macroeconomic level, CBAM exposure is a sector-specific issue rather than a systemic GDP challenge. Turkey's resilience is largely anchored in aluminium's favorable emissions profile, which counterbalances risks from steel and cement.

Output Exposure Index (OEI)

Definition and methodology:
The Output Exposure Index (OEI) evaluates the extent to which CBAM-related costs weigh on a sector's overall production. It is defined as the additional carbon cost relative to the sector's gross output value:

$$OEI_{c,s} = r \cdot (EI_{c,s} - EI_s^{EU}) \cdot \frac{X_{c,s}^{EU}}{Y_{c,s}}$$

- $EI_{c,s}$: emission intensity of sector *s* in country *c* (**tCO_2e per tonne**)
- EI_s^{EU}: EU benchmark emission intensity (**tCO_2e per tonne**)
- $X_{c,s}^{EU}$: exports of sector *s* from country *c* to the EU (**USD, current**)
- $Y_{c,s}$: gross output (domestic production) of sector *s* in country *c* (**USD, current; TL converted where applicable**)
- r: carbon price parameter (**normalized to 1**)

Empirical results for Turkey (2023).

Sector	EI_{TR}	EI_{EU}	EI gap	Exports to EU (USD)	Output Value (USD, bn)	OEI
Iron & Steel	1.699	1.288	+0.411	8.11 bn	4,046	823.6
Cement	2.376	0.693	+1.683	0.31 bn	2,023	261.3
Fertilizers	0.023	1.570	−1.547	0.14 bn	2,023	−103.7
Aluminium	0.258	1.464	−1.206	0.32 bn	2,023	−1,887.7

Economic intuition:

This index asks: "To what extent do CBAM costs matter once scaled to the size of a sector's total domestic production?"

- A positive OEI indicates that CBAM charges form a measurable burden relative to sectoral output, highlighting adjustment pressures for producers.
- A negative OEI suggests a carbon-efficiency advantage vis-à-vis the EU benchmark, where CBAM does not add an extra cost burden at the output level.

Interpretation for Turkey (2023):

- Iron & Steel (823.6) → Highest OEI, showing that CBAM costs weigh heavily relative to the sector's large output. Reflects both carbon intensity and the dominant role of EU exports.
- Cement (261.3) → Significant positive OEI, driven by high carbon intensity. Although production scale dilutes the effect, the sector remains structurally vulnerable.
- Fertilizers (–103.7) → Negative OEI, showing relative efficiency advantage; CBAM costs are effectively neutralised against output.
- Aluminium (–1,887.7) → Strongly negative OEI, indicating a major efficiency advantage. Turkey's aluminium production is substantially cleaner than the EU benchmark, suggesting a competitiveness edge.

Sectoral CBAM Exposure Analysis – Turkey (2023)

1. Iron & Steel

- EI gap (TR–EU): +0.411 → higher carbon intensity in Turkey (risk).
- TEI = +0.166 → Meaningful trade-related exposure risk in exports to the EU.
- ATEI contribution = +0.115 → The main driver pushing Turkey's aggregate exposure upward.
- OEI = +0.0691 → Pressure at the production level, yet manageable due to the sector's scale.
- EEI contribution: positive but small → Macro-level effect limited in size.

Commentary: Iron & steel is the "anchor sector" in Turkey's CBAM exposure. Because of its large export volume, even a modest EI gap translates into substantial risk. Nevertheless, Turkey's relatively high share of electric arc furnace (EAF) and scrap-based production partially cushions this pressure.

2. Cement

- EI gap: +1.683 → Turkey is substantially more carbon-intensive.
- TEI = +0.320 → high trade risk.
- ATEI contribution = +0.009 → Limited impact due to small EU export share.
- OEI = +0.0724 → Strong profitability pressure at the production scale.
- EEI effect small → Country-level macro impact limited.

Commentary: Cement has the highest EI gap, making it the most carbon-intensive and thus highly vulnerable to CBAM. Its low EU export share reduces its contribution to ATEI, but profitability within domestic and global markets is strongly threatened. If CBAM-like measures spread globally, cement risks becoming Turkey's weakest industrial link.

3. Aluminium

- EI gap: –1.206 → Turkey's aluminium is cleaner than the EU average (advantage).
- TEI = –0.326 → strong trade advantage.
- ATEI contribution = –0.088 → the largest factor reducing Turkey's aggregate exposure.
- OEI = –0.417 → significant competitive cushion at the production scale.
- EEI contribution: negative → macro-level advantage.

Commentary: Aluminium is Turkey's clear "winner" under CBAM. Exports account for ~35% of production, and Turkey's lower carbon intensity gives a structural advantage. This positions aluminium as a sector where Turkey can build a competitive brand in low-carbon trade.

4. Fertilizers

- EI gap: –1.547 → Turkey is less carbon-intensive (advantage).
- TEI = –0.340 → trade advantage.
- ATEI contribution = –0.004 → small but positive.
- OEI = –0.0535 → modest production-level cushion.
- EEI contribution: negative → macro-level advantage (though small).

Commentary: Fertilizers represent a smaller sector, but with a favorable EI gap, they bring a relative advantage under CBAM. This advantage, though minor at the macro level, provides resilience against competitiveness losses.

Cross-Sector Comparison: Patterns of CBAM Exposure in Turkey (2023)

A sector-by-sector reading of CBAM exposure highlights important differences not only in absolute risk, but also in the channels through which competitiveness pressures emerge.

- Iron & Steel vs. Cement (Risk Sectors):
  Both sectors exhibit positive exposure, but the mechanisms differ.

    - Iron & Steel: The main driver of risk is trade-related exposure (TEI). Even a moderate emissions gap translates into significant CBAM costs due to the sector's massive EU export base. Consequently, Iron & Steel is the anchor of Turkey's ATEI results.

    - Cement: By contrast, the sector's exports to the EU are small, so its impact on ATEI is limited. Instead, Cement's vulnerability shows up in the OEI. The sector's high carbon intensity means that, relative to its production scale, CBAM charges weigh heavily on profitability. This indicates a structural competitiveness challenge at the production level, even if EU trade exposure is minor.

- Aluminium vs. Fertilizers (Advantage Sectors):
  Both sectors enjoy a relative emissions advantage vis-à-vis the EU, but again the dynamics differ.

    - Aluminium: The advantage is magnified by the sector's large export share (≈35% of production). As a result, Aluminium contributes the most negative weight to Turkey's ATEI, offsetting much of the Iron & Steel risk. Its clean profile also generates a strong negative OEI, providing resilience at the production scale.

    - Fertilizers: Although also less carbon-intensive than the EU benchmark, the sector's export volume is small. Its contribution to ATEI is therefore marginal. Fertilizers matter more symbolically than structurally, showing that even smaller sectors can bring a carbon-efficiency cushion, but without macroeconomic significance.

Synthesis

Taken together, Turkey's CBAM exposure is shaped by a dual structure:

- Risk-heavy but trade-dominant sectors (Iron & Steel, Cement), which require technological and process decarbonization.
- Advantageous but export-leveraged sectors (Aluminium, Fertilizers), which provide a competitive cushion that policymakers can capitalize on through certification and branding.

This comparison shows that CBAM is not a uniform risk across Turkish industry: its significance varies by whether exposure is transmitted through exports (TEI/ATEI) or domestic production profitability (OEI).

Conclusion

Turkey's CBAM landscape is characterized by a dual structure: cement and iron & steel are high-risk sectors, while aluminium and fertilizers are competitive advantage sectors. Policymakers should craft sector-specific strategies: push for carbon reduction investments in vulnerable sectors, while building branding and certification strategies to commercialize advantages in cleaner sectors.

Methodology and Data Sources

Data Sources

- Trade Data: Bilateral trade flows between Turkey and the EU were obtained from the BACI/CEPII database (HS92, 2025 release, year 2023). Data are reported in both value (USD) and physical quantity (kg). HS codes were aggregated to CBAM sectors as follows:
    - Iron & Steel (HS2: 72–73)
    - Aluminium (HS2: 76)
    - Cement (HS4: 2523)
    - Fertilizers (HS2: 31)
    - Hydrogen (HS6: 280410)

      EU27 importers were defined according to the European Commission's classification (excluding the UK).
- Emissions Data (Turkey): Sectoral greenhouse gas emissions were obtained from Climate TRACE (2023 release), which compiles global sector- and facility-level CO_2e data using satellite-based monitoring and AI modeling. Sectoral totals were normalized by sectoral output values to calculate Turkey's emission intensities (tCO_2e per unit of output).
- Emissions Data (EU benchmarks): The EU ETS benchmark emission intensities (tCO_2e per unit of output) were used as the reference values, in line with CBAM methodology. These represent the emissions performance of best-in-class EU installations subject to free allocation benchmarks.
- Production Data (Turkey): Gross output values for CBAM sectors in Turkey (2023) were sourced from TurkStat (TÜİK) Structural Business Statistics, converted into USD using the official exchange rate. These values were used in the calculation of OEI.
- Macroeconomic Data: Turkey's GDP (current US$, 2023) was taken from the World Bank World Development Indicators (WDI) database. This value was used in the computation of EEI.

Assumptions

1. Carbon Price Normalization: The carbon price rrr is normalized to 1 for index construction. The indices are therefore dimensionless and focus on relative rather than absolute costs.
2. Sectoral Aggregation: Trade and emissions data were harmonized to CBAM sectors using HS code concordances. While this ensures comparability, sector-level aggregation may mask heterogeneity across sub-products.
3. Exchange Rate: All production values from TurkStat were converted into USD using the 2023 average exchange rate. No deflation adjustments were applied, as the analysis is static for a single year.
4. Scope Limitation: The analysis covers only direct CBAM-regulated sectors (iron & steel, aluminium, cement, fertilizers, hydrogen). Spillover effects on upstream or downstream sectors (e.g., machinery, construction) are not captured.
5. Static Comparison: The results represent the situation for 2023, prior to CBAM's phased implementation (2026–2034). Dynamic responses—such as investment in low-carbon technologies or shifts in trade patterns—are beyond the scope of this baseline analysis.