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Environmental Ambition and Economic Protectionism: Why the Design of Border Carbon Adjustments Matters

Border carbon adjustments (BCAs) are becoming a central instrument in climate-trade policy to limit carbon leakage while protecting domestic industry. Their effectiveness, however, depends fundamentally on how they are designed. In this ZEW policy brief, mass-based BCAs (e.g. the Carbon Border Adjustment Mechanism (CBAM) in the EU), which price total embodied emissions, are compared with rate-based proposals, which price only emissions above an intensity benchmark. Drawing on new research on the global steel industry, we show that a rate- or benchmark-based BCA combines an emissions charge with an implicit output subsidy. That weakens the carbon-price signal, encourages exporters to reshuffle cleaner output towards regulated markets, and can induce vertical leakage through underpriced intermediates such as pig iron. In an EU-style setting with domestic carbon pricing, the rate-based design transmits only 36% of the mass-based border price needed to achieve the same global emissions reduction. In a US-style setting without a domestic price anchor, it functions less as a climate instrument and more as an industry tariff that shifts scarcity rents toward domestic downstream users.



POLICY RECOMMENDATIONS

- Use mass-based BCAs as the default, especially upstream: Policymakers should generally favour mass-based architectures that charge for total embodied emissions. They transmit the carbon price more directly, are harder to arbitrage in homogeneous upstream markets, and are better aligned with the environmental objective of reducing global emissions.
- Anchor border measures in domestic carbon pricing: A BCA is most credible when it extends an existing domestic carbon price to imported products. Without this anchor, especially under rate-based designs, the measure mainly reallocates rents toward domestic downstream users and provides little incentive for abatement abroad.
- Cover the full supply chain and monitor intermediates: Regulations should track embodied emissions across upstream inputs such as pig iron and semi-finished steel. Otherwise exporters can reshuffle cleaner output or rely on underpriced carbon-intensive intermediates, undermining the environmental integrity of the policy.
- Preserve the scale incentive in consumption: Effective climate policy requires that at least part of the carbon cost reaches steel users and final consumers. If governments use benchmarked designs to cushion downstream price increases, they should pair them with complementary charges or domestic carbon pricing that restore demand-side incentives and generate revenue for recycling.

THE ARCHITECTURE OF BORDER CARBON ADJUSTMENTS

As major economies raise climate ambition, a central challenge emerges: how to price carbon at home without shifting production to jurisdictions with weaker regulation? This risk of carbon leakage threatens both emissions goals and industrial competitiveness. BCAs aim to address both concerns by charging imports for the emissions embodied in traded goods at the border. Yet governments are favouring on different BCA architectures. The EU’s Carbon Border Adjustment Mechanism (CBAM) follows a mass-based approach: Importers pay for the full embodied emissions of a product. In US policy debates, benchmarked rate-based designs are more prominent. The PROVE IT Act would build the emissions-intensity data needed for such policies, while proposals such as the Foreign Pollution Fee Act would link import charges to pollution intensity relative to a benchmark. The choice between these designs is not administrative fine print. It determines how much climate ambition is transmitted abroad and which parts of the supply chain receive protection.

Limiting carbon leakage while preserving competitiveness

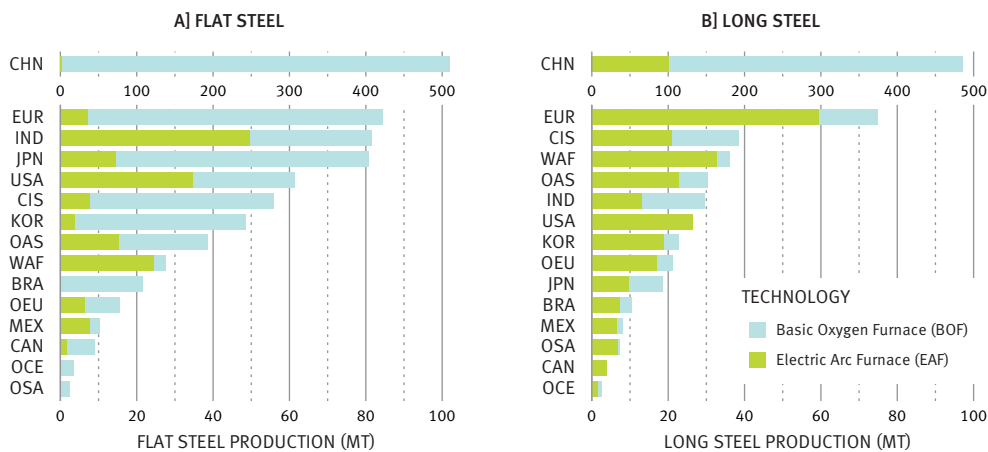
Pricing of emissions is the key design choice

THE HIDDEN SUBSIDY IN RATE-BASED DESIGNS

The economic problem with rate-based BCAs is that they are not pure carbon prices. Because importers pay only for emissions above a benchmark, the benchmark effectively grants a credit for every unit of output. The result is an implicit output subsidy: The policy charges carbon, but it also rewards volume. The incentives for foreign producers to cut emissions are weaker than the headline border price suggests.

Rate-based designs weaken the carbon price signal

FIGURE 1: COMPARISON OF STEEL PRODUCTION ROUTES ACROSS KEY REGIONS



Notes: The chart distinguishes between flat steel (sheets and plates used in automotive and appliances) and long steel (bars and beams used primarily in construction). Flat products rely more heavily on integrated BF-BOF plants, while long products are more often produced in scrap-based EAFs. This heterogeneity makes reshuffling possible: Exporters can divert existing cleaner EAF output towards regulated markets without reducing their overall emissions. The world regions include: the EU-28 and the European Free Trade Association (EUR), the United States (USA), China (CHN), India (IND), Japan (JPN), South Korea (KOR), Other Asia (OAS), Oceania (OCE), Canada (CAN), Mexico (MEX), Brazil (BRA), Other South America (OSA), Turkey and Other Europe (OEU), the Commonwealth of Independent States and Ukraine (CIS), as well as West Asia and Africa (WAF). Source: Park, Rausch, and Karplus (2026).

Our analysis quantifies this weakening of the price signal. In an EU-style setting with domestic carbon pricing, the rate-based design transmits only 36% of the mass-based border price that achieves the same global emissions reduction. Put differently, the benchmark acts like a 64% discount on the border carbon price. In a US-style setting without a domestic carbon-price anchor, the effective signal falls to about one-eighth of the mass-based benchmark. A government may announce a high nominal border fee, but the climate incentive reaching the foreign mill can be far smaller.

Rate-based BCA significantly smaller compared to EU border price

THE COMPLEXITY OF GLOBAL STEEL SUPPLY CHAINS

The steel supply chain helps to explain why benchmarked border measures can underperform. Steel is produced through two main routes: the carbon-intensive blast furnace-basic oxygen furnace (BF-BOF) route using iron ore, and the cleaner electric arc furnace (EAF) route using scrap. Many global firms operate both types of plants. Under a rate-based BCA, those firms can reshuffle by sending cleaner EAF output to the regulated market while continuing to sell more carbon-intensive BF-BOF steel elsewhere.

Plant heterogeneity lets exporters reshuffle existing cleaner output toward regulated markets

Figure 1 highlights how much technological heterogeneity exists across regions and products. The differences matter because they allow exporters to comply partly through reallocation rather than through real emissions reductions. The easier it is for firms to reassign existing clean output across destinations, the less the border measure changes global emissions.

Steel is also a vertically linked industry. Downstream steelmakers can buy carbon-intensive intermediates such as pig iron or semi-finished slabs from abroad. If a BCA only imposes a low price on these upstream inputs, firms can reduce their emissions declared at the border without cleaning up the underlying supply chain. This is the vertical leakage channel. Mass-based BCAs are more powerful because they price total embodied emissions rather than only the gap to a benchmark.

Underpriced intermediates create a channel for vertical leakage

ECONOMIC EFFICIENCY VS. POLITICAL PROTECTIONISM

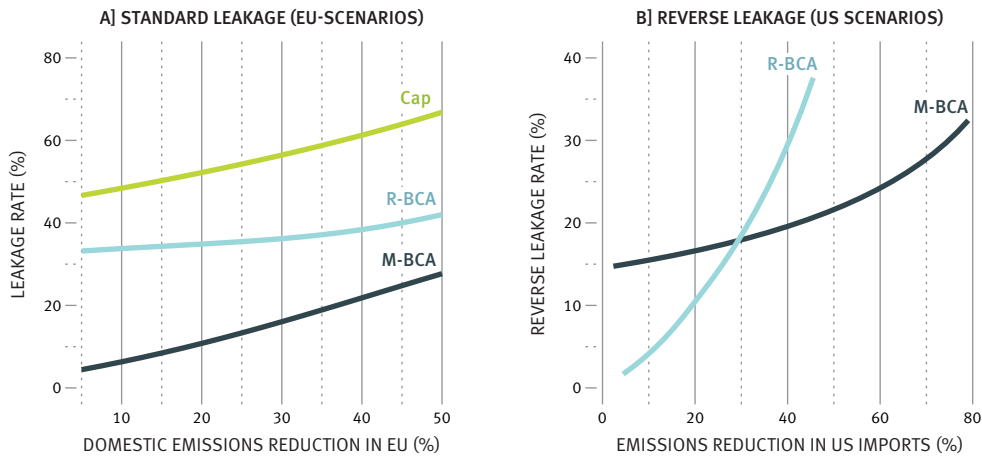
Mass-based BCAs are also more cost-effective. They activate two adjustment channel at once: the technology margin, which encourages cleaner production, and the scale margin, which raises the relative price of carbon-intensive goods and thus reduces demand. Rate-based designs weaken the second channel because the implicit output subsidy shields downstream users from part of the carbon cost. As a result, they rely more on changes in sourcing and production composition, which are associated with higher costs.

Cost efficiency leads to technology and scale margins

This creates the central trade-off between environmental ambition and economic protection. Benchmark designs can be politically attractive because they soften price increases for downstream industries such as construction and automotive manufacturing. But that protection comes at a cost. In our EU-style comparison, the rate-based design delivers less global abatement and raises welfare losses by about 55% relative to the mass-based alternative. In the US-style setting, the corresponding rate-based border measure delivers only about one-quarter of the global emissions reduction that would be achieved by a comparable mass-based charge. Without a domestic carbon price extending to the border, the policy functions mainly as an industry tariff, shifting scarcity rents towards domestic downstream users rather than inducing any significant abatement abroad.

A domestic carbon-price anchor is an important climate instrument

FIGURE 2: STANDARD LEAKAGE VS. REVERSE LEAKAGE UNDER ALTERNATIVE BCA DESIGNS



Notes: This figure compares three scenarios. “Cap” shows a domestic-only carbon price without a border measure and therefore standard leakage. A mass-based BCA (M-BCA) prices full embodied emissions at the border. A rate-based BCA (R-BCA) prices only emissions above a benchmark and therefore embeds an output subsidy. Panel (a) shows the EU-style case, where the border measure complements domestic carbon pricing. Panel (b) shows the US-style case, where the border instrument operates without a domestic price anchor and may induce reverse leakage, that is, the onshoring of carbon-intensive production. Source: Park, Rausch, and Karplus (2026)

Figure 2 illustrates the sharp difference between the EU and US policy environments. Where a BCA complements an existing domestic carbon price, the key question is how effectively the border instrument transmits that climate signal abroad. If no domestic price exists, the border measure mainly redistributes climate protection across the supply chain and may even encourage reverse leakage by pulling production onshore without generating meaningful global emissions reductions.

CONCLUSION: ACHIEVING A CREDIBLE CARBON PRICE SIGNAL

The design of a BCA is not a technical detail. It determines whether the policy primarily transmits climate ambition abroad or primarily reallocates protection at home. In the steel industry, mass-based designs are more effective because they preserve the carbon-price signal, limit reshuffling and better capture emissions embodied in traded intermediates.

For policymakers, the lesson is not that every sector needs the same instrument. Rather, the architecture should match industrial structure. Mass-based treatment is especially important for homogeneous upstream materials and vertically linked supply chains. Benchmarked designs are harder to justify unless they are integrated in a domestic carbon pricing scheme and complemented by measures that restore demand-side incentives. As the EU refines the CBAM and the US considers its own path, credible climate-trade policy will depend on transparent carbon pricing across the supply chain.

Mass-based designs are more effective in the steel industry

Credible climate-trade policy needs transparent carbon pricing along the entire supply chain

REFERENCE

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