Impact of the EU's Carbon Border Adjustment Mechanism and Canada's carbon pricing: A partial equilibrium approach to Canada's steel sector

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Abstract

Recent research on the EU's Carbon Border Adjustment Mechanism (CBAM) has emphasized its impact on countries with limited carbon pricing. For advanced economies such as Canada, however, the challenge lies in navigating the final and most difficult stages of industrial decarbonization. This study evaluates the effectiveness and limits of conventional climate policies in sectors that have already undergone partial technological transition. We ask whether carbon pricing and border adjustments can drive deep decarbonization, or whether they instead accelerate industrial contraction. Using a multi-technology partial equilibrium model of Canada's steel sector—distinguishing between legacy blast furnace-basic oxygen furnace (BF-BOF) and cleaner electric arc furnace (EAF) technologies—we simulate four policy pathways. The results highlight a critical distinction between "growth-led" decarbonization, where low-emission production expands in absolute terms, and "recession-led" decarbonization, where its relative share rises mainly because of the decline of carbon-intensive output and overall contraction. We find that a domestic Border Carbon Adjustment (BCA) can uniquely support a "growth-led" pathway, but this outcome is fragile and highly sensitive to geopolitical conditions, particularly policy asymmetry with the United States. Other scenarios, including the status quo, yield only "recession-led" decarbonization. We conclude that for advanced economies, carbon pricing and BCAs are necessary but insufficient first-generation policies. Their main effect is to phase out inefficient incumbents rather than to induce transformative investment. Completing the transition will require complementary second-generation policies designed to overcome the high capital barriers facing next-generation clean technologies.

Keywords: Carbon Border Adjustment Mechanism (CBAM); Carbon Pricing; Border Carbon Adjustment (BCA); Partial Equilibrium Modeling; Steel Sector Decarbonization; Technological Transition; Growth-led vs Recession-led Decarbonization; Trade and Political Risk

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1. Introduction

The European Union's Carbon Border Adjustment Mechanism (CBAM) has intensified global debate on the intersection of climate and trade policy. While much of the literature emphasizes the initiation of carbon pricing in emerging economies, a more complex challenge confronts advanced nations such as Canada. Having already progressed in industrial decarbonization, these countries may be approaching diminishing returns, where existing "first-generation" policies such as carbon pricing are insufficient to drive the capital-intensive final stages of transition. This raises a critical question: can these established tools still foster genuine technological transformation, or do they risk inducing deindustrialization?

Canada illustrates this dilemma sharply. With an ambitious federal carbon price, its carbon-intensive industries, including steel, face dual pressures: high domestic compliance costs and structural disadvantages relative to trading partners without equivalent policies. The core issue is not CBAM itself—Canada's price largely shields it from the EU levy—but rather policy asymmetry with the United States. This imbalance threatens Canadian competitiveness in the integrated North American market, where import substitution could generate carbon leakage.

This study directly examines this advanced-economy dilemma by analyzing the effects of carbon pricing and border measures on Canada's steel sector. Prior work, often using Computable General Equilibrium (CGE) models, has highlighted domestic Border Carbon Adjustments (BCAs) as a potential remedy (Jebeli et al., 2024). However, such studies frequently neglect two crucial dimensions. First, they lack sectoral granularity to distinguish the "quality" of decarbonization—whether it reflects a genuine "growth-led" technological shift, such as an absolute increase in electric arc furnace (EAF) production, or a "recession-led" outcome driven by contraction of blast furnaces (BF-BOF). Second, they often overlook the geopolitical risks inherent in a BCA, particularly the prospect of U.S. retaliation.

To address these gaps, we employ a multi-technology partial equilibrium model to simulate four policy scenarios for Canada's steel sector: (1) maintaining the carbon price trajectory, (2) repealing the price from 2027, (3) implementing a Canadian BCA without retaliation, and (4) a scenario in which a BCA triggers a 25% retaliatory U.S. tariff. This framework highlights the trade-offs Canada faces between competitiveness, deep decarbonization, and geopolitical stability.

By integrating sectoral detail with explicit modeling of political risk, this study makes a broader contribution. It provides the first quantitative evidence for the concept of "recession-led" decarbonization in an advanced economy, showing how conventional policies can primarily phase out incumbents rather than induce transformative investment. The findings reveal the fragility of conditions required for a "growth-led" alternative and demonstrate that for advanced economies, "first-generation" policies such as carbon pricing and BCAs are necessary but insufficient to complete the green transition.

The remainder of the paper is organized as follows: Section 2 reviews the literature; Section 3 describes the Canadian steel sector; Section 4 presents the methods; Section 5 reports results; Section 6 discusses policy implications and concludes.

2. Literature Review

Recent studies on the EU's Carbon Border Adjustment Mechanism (CBAM) have employed Computable General Equilibrium (CGE) models to assess its macroeconomic effects, including mitigation of carbon leakage and changes in global trade patterns (Bellora & Fontagné, 2023; UNCTAD, 2021). A common conclusion is that advanced economies such as Canada, which already apply domestic carbon pricing and maintain relatively cleaner production processes, are only marginally affected by CBAM compared to developing countries with more carbon-intensive exports. This finding, however, masks more complex indirect challenges.

A key limitation of many CGE studies is their aggregation of industries into broad sectors, which restricts their ability to capture technological heterogeneity. This is particularly relevant for steel, where production is divided between high-emission blast furnace-basic oxygen furnaces (BF-BOF) and low-emission electric arc furnaces (EAF) (Jebeli et al., 2024; Chen, 2023). While CBAM could, in principle, incentivize technology switching, quantitative analysis of this mechanism at a disaggregated level remains scarce. Our study addresses this gap by using a partial equilibrium model that explicitly distinguishes between BF-BOF and EAF, allowing us to evaluate the "quality" of decarbonization—whether it reflects genuine technological change or simple deindustrialization.

In the Canadian context, existing research often highlights a domestic Border Carbon Adjustment (BCA) as a strategic response to CBAM, again relying on macroeconomic modeling (Jebeli et al., 2024). While such approaches help clarify Canada's position in global trade and the importance of coordination, they tend to treat BCA as a purely technical instrument. This risks overlooking firm-level and sector-specific responses and, more importantly, neglects quantitative evaluation of a key barrier to adoption: the risk of geopolitical friction and retaliatory measures from the United States, which lacks a federal carbon price.

The literature has also paid limited attention to domestic policy uncertainty. Most studies assess CBAM and BCA under fixed policy assumptions and rarely consider how political dynamics, such as electoral outcomes or the potential repeal of a carbon tax, could alter their effectiveness. Yet policy stability is a critical condition for long-term investment in decarbonization.

This study addresses these gaps in three ways. First, by differentiating production technologies, it provides a sector-specific analysis of structural decarbonization pathways. Second, it incorporates political uncertainty by modeling a carbon tax repeal scenario. Third, it extends beyond economic assessment by introducing a retaliatory tariff scenario, thereby quantifying the geopolitical risks associated with a BCA. Taken together, this framework offers a more robust and policy-relevant analysis for a carbon-pricing advanced economy navigating an increasingly complex international environment.

3. Overview of Canada's Steel Sector

The Canadian steel sector is a core component of the national manufacturing base and is deeply integrated into the North American market. To establish a stable pre-policy baseline for the model, this study draws on a 10-year average (2014–2023) for macroeconomic indicators and a pre-pandemic average (2017–2018) for trade partner shares.

Between 2014 and 2023, Canada's annual crude steel production averaged 12.56 million tonnes (Mt). Apparent consumption was higher, averaging 14.91 Mt, indicating structural reliance on foreign supply. This gap was met through net imports: imports averaged 8.61 Mt per year, while exports averaged 6.27 Mt (World Steel Association, 2024). These baseline values—summarized in Table 1—form the calibration targets for the partial equilibrium model.

Production is divided between two main technologies, reflecting a sector already in transition. The traditional, carbon-intensive blast furnace-basic oxygen furnace (BF-BOF) process accounted for 56.9% of output, while the lower-carbon electric arc furnace (EAF) process, which primarily uses scrap steel, accounted for 43.1%. This technological heterogeneity is central to our analysis. Emission factors are 1.389 tCO_2/t for BF-BOF and 0.417 tCO_2/t for EAF, underscoring how the sector's decarbonization trajectory depends on the relative competitiveness of these two processes under carbon pricing. The significant existing EAF share also suggests that the most accessible opportunities for emissions reduction may already have been realized, making further shifts more challenging.

Canada's steel trade is overwhelmingly oriented toward the United States. Based on 2017–2018 UN Comtrade data, the U.S. absorbed roughly 90% of Canadian steel exports, making it the sector's indispensable market. By contrast, exports to the EU—the originator of CBAM—accounted for less than 1%. On the import side, the U.S. was also the dominant source, supplying nearly 50% of Canada's steel imports. This deep integration with a jurisdiction lacking a federal carbon price is a defining feature of the sector. It provides the essential context for this study: any domestic or international climate policy must be evaluated primarily in terms of its implications for North American competitiveness and the bilateral relationship with the United States.

Table 1: Overview of Canada's Steel Industry

Metric	**Average**
Canada's production quantity (in million tonnes)	13.3
Canada's use quantity (in million tonnes)	14.1
Export quantity with the EU (in million tonnes)	1.104
Import quantity with the EU (in million tonnes)	9.166
Export quantity with top 5 non-EU (in million tonnes) (USA, China, Mexico, Brazil, Germany)	15.776
Import quantity with top 5 non-EU (in million tonnes) (USA, China, Korea, Japan and Germany)	14.026

Note: Data sources are World Steel in Figures and the UN Comtrade Database. All figures represent a three-year annual average for 2017–2019.

Table 2: Production Technology, Emission Intensity, and Trade Orientation

Category	Metric	Value
Production Structure & Emissions		
Technology Share	BF–BOF Share	~56.9%
	EAF Share	~43.1%
Emission Intensity	BF–BOF (tCO_2/t)	1.389
	EAF (tCO_2/t)	0.417
Trade Orientation (2017–2018 Average)		
Export Destinations	Share to USA	~90%
	Share to EU	<1%
Import Origins	Share from USA	~50%
	Share from EU	~11%

Note: Technology shares and emission intensities are based on model calibration parameters. Trade orientation shares are calculated from UN Comtrade data for the pre-pandemic period of 2017–2018 to reflect stable trade patterns.

4. Research Methods and Methodology

This study employs a multi-technology, multi-country partial equilibrium (PE) model to assess the combined impacts of the EU's Carbon Border Adjustment Mechanism (CBAM) and Canada's domestic carbon pricing policies. For all percentage-change results, we define the no-policy baseline as the 2025–2030 equilibrium path under zero carbon pricing and no CBAM. This baseline serves as the counterfactual against which all policy scenarios are evaluated.The choice of a PE framework, rather than a Computable General Equilibrium (CGE) model, is deliberate. It enables the granular, sector-specific analysis required to investigate our central research question: the quality of decarbonization in an advanced industrial sector. By explicitly modeling the competition between BF-BOF and EAF production technologies, we isolate the direct effects of carbon costs on intra-industry substitution. This focus is essential for distinguishing between "growth-led" technological upgrading and "recession-led" shifts driven by deindustrialization, an insight often obscured in economy-wide models. Our model builds on the methodology of Chu et al. (2024) but is substantially adapted to the context of a carbon-pricing advanced economy.

4.1. Model Calibration: Data, Assumptions, and Baseline

The model is calibrated to a carefully constructed baseline designed to reflect the Canadian steel sector's structural characteristics prior to the disruptions of the COVID-19 pandemic and subsequent inflationary pressures.

4.1.1. Baseline Data Selection

To ensure robustness, the baseline combines two periods. For aggregate indicators such as production, consumption, and trade volumes, we use a 10-year annual average (2014–2023, World Steel Association, 2024). This longer window smooths cyclical fluctuations and provides a stable structural baseline. For more granular indicators, specifically the distribution of trade with key partners (USA, EU, etc.), we employ a 2-year pre-pandemic average (2017–2018, UN Comtrade). This captures recent, stable trade patterns before they were distorted by the pandemic and supply chain shocks. The key baseline parameters derived from these data are detailed in Section 3 (Tables 1 and 2).

4.1.2. Technological and Emissions Parameters

A core feature of our model is the explicit differentiation between the two dominant steel production technologies. Based on industry data, we set the output share of BF-BOF at 56.9% and EAF at 43.1%. Emission intensities are calibrated at 1.389 tCO_2/t for BF-BOF and 0.417 tCO_2/t for EAF. This three-fold difference is the main driver of intra-sectoral substitution effects under carbon pricing, allowing us to test the hypothesis that "first-generation" policies have limited capacity to induce further structural change once initial shifts have been realized.

4.1.3. Modeling Canada's Output-Based Pricing System (OBPS)

A simple carbon tax would overstate the burden on Canadian industry. To reflect reality, the model incorporates the key feature of Canada's Output-Based Pricing System (OBPS), which grants emissions allowances to trade-exposed industries. We assume exemptions of 90% for BF-BOF and 95% for EAF, consistent with technology-specific benchmarks. Domestic carbon revenues are calibrated against official government projections of national industrial carbon pricing revenues. The steel sector's likely share is derived and an effective_collection_rate parameter is applied to ensure that the model's fiscal outcomes align with macroeconomic forecasts. This ensures that, while partial equilibrium in structure, the model's fiscal outputs remain consistent with broader economic realities (see Appendix B).

4.2. Policy Scenarios

We simulate the period 2025–2030, modeling four policy pathways. These scenarios capture the strategic options facing Canadian policymakers and allow us to test the conditions under which different qualities of decarbonization emerge. Carbon price trajectories for Canada and the EU are reported in Table 3, with all prices converted to USD.

1. **Status Quo (CBAM-only):** Canada maintains its federal carbon price increases, reaching 170 CAD/tCO_2 by 2030. The sector faces rising domestic costs and the EU's CBAM, with no additional border measures. This serves as the reference scenario.
2. **BCA without Retaliation:** From 2026, Canada implements a Border Carbon Adjustment with three features: (i) a levy on imports equal to the differential between Canada's carbon price and that of the origin country, (ii) a 20% rebate on the domestic carbon cost of exports, and (iii) retention of revenue from import levies and export differentials. This optimistic scenario assumes acceptance by trading partners.
3. **BCA with U.S. Retaliation:** Same as Scenario 2, but from 2026 the United States imposes a 25% retaliatory tariff on Canadian steel exports, modeled as an ad valorem increase in U.S. market prices. The 25% rate reflects the historical precedent of Section 232 tariffs.
4. **Carbon Tax Repeal:** From 2027, the federal carbon price is fully repealed. Producers avoid domestic carbon costs but face the full CBAM levy on exports, as no domestic carbon price can be credited.

4.3. Equilibrium Model and Simulation

The model solves for a market-clearing equilibrium price where total domestic supply (BF-BOF plus EAF) equals total demand (domestic consumption plus exports). Equilibrium depends on four behavioral elasticities: (1) supply, (2) export demand, (3) domestic consumption, and (4) substitution between domestic and imported goods.

To account for uncertainty, we employ Monte Carlo simulation. For each scenario, the model is run 1,000 times, with elasticity values drawn from uniform distributions based on the empirical literature (Table 3). This stochastic approach generates mean impacts and 95% confidence intervals, providing a robust assessment of the likely range of outcomes. Full mathematical details, including equilibrium conditions and policy implementation, are provided in Appendix A.

Table 3: Key Policy and Model Parameters

Parameter	**Assumption / Value**	**Primary Source / Justification**
Carbon Price Trajectories (USD/tCO$_2$ in 2030)		
Canada	\$126 (equivalent to \$170 CAD)	Government of Canada (2022)
EU (ETS)	\$173 (equivalent to 160)	European Environment Agency (2023)
BCA and Retaliation Design (from 2026)		
Import Levy	Full carbon price differential	Standard BCA design principle
Export Rebate	20% of domestic carbon price	Conservative assumption
U.S. Retaliation Tariff	25% ad valorem on steel exports	Historical precedent (Section 232 Tariffs)
Elasticity Ranges for Monte Carlo Simulation		
Price elasticity of supply	[0.5, 2.5]	Fally & Sayre (2018)
Price elasticity of export demand	[2.0, 5.0]	Ahmad & Riker (2020)
Price elasticity of consumption	[0.2, 0.8]	Fernandez (2018)
Elasticity of substitution	[2.0, 4.5]	Ahmad & Riker (2020)

5. Results

Our simulations reveal four markedly different transition pathways for the Canadian steel sector, driven by the interaction of domestic carbon pricing, border measures, and geopolitical risks. We present two complementary sets of results. Figure 1 provides a high-level summary of the *quality* of decarbonization achieved in each scenario by comparing changes in total output and in the production of low-emission EAF steel in 2030. This "Decarbonization Quality Map" visually distinguishes between (i) *growth-led* decarbonization, in which clean production increases in absolute terms, and (ii) *recession-led* decarbonization, in which the sector appears cleaner largely because carbon-intensive output contracts.

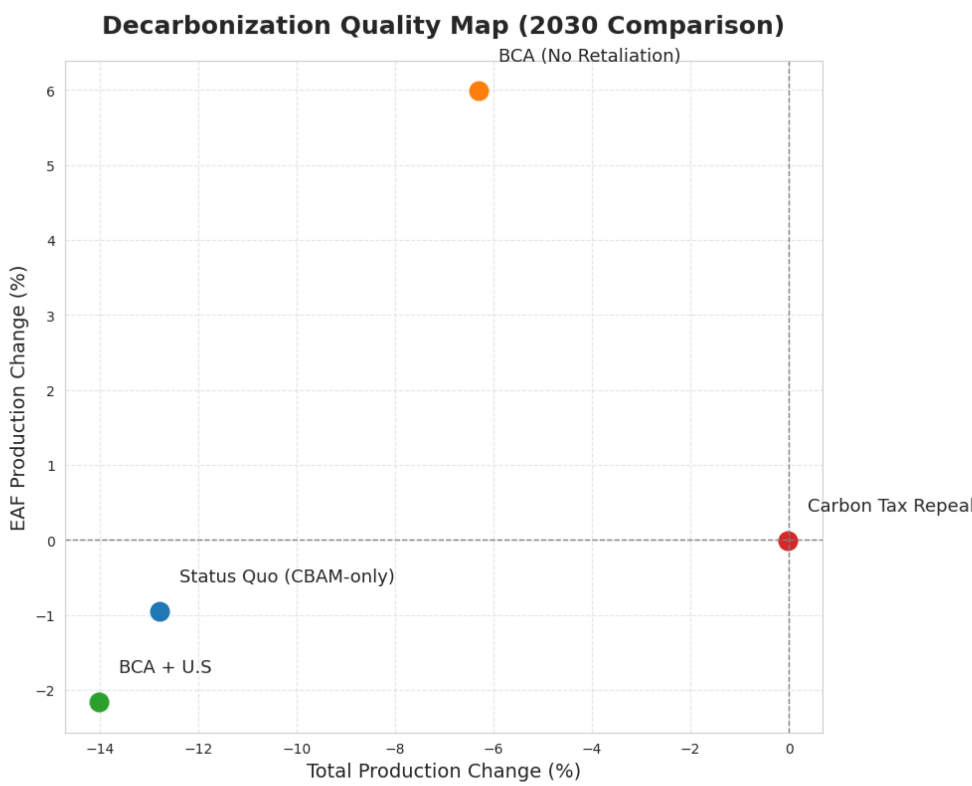

Figure 1: Decarbonization Quality Map (2030)). *Note:* Horizontal axis reflects the percentage change in total steel output relative to the no-policy baseline; the vertical axis shows the percentage change in EAF production. The upper-right quadrant represents "growth-led" decarbonization in which clean production expands in absolute terms.

In addition to the overall quality of decarbonization, it is essential to examine how the technology mix and emission intensity evolve across scenarios. Figure 2 summarizes changes in the shares of BF–BOF and EAF production, as well as the average emission intensity of output, over the 2025–2030 period. This cross-scenario comparison shows that while all pathways yield some reduction in emission intensity, only the BCA without retaliation scenario produces a substantial increase in the EAF share. In the Status Quo and Retaliation scenarios, improvements in emission intensity are driven primarily by contraction of BF–BOF capacity rather than the expansion of cleaner technologies.

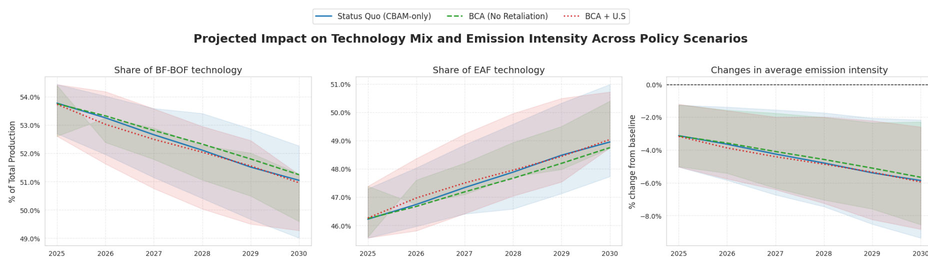

Figure 2: Projected Impact on Technology Mix and Emission Intensity Across Policy Scenarios (2025–2030). Shaded areas represent 95% confidence intervals.

5.1. *Scenario 1: A "Recession-Led" Default Future (Status Quo)*

The continuation of carbon pricing without a BCA leads to a clear case of recession-led decarbonization. By 2030, total production declines by 12.8% from the baseline (Figure 3, Table 4), while untaxed imports increase by 5.7%. This pressure falls disproportionately on BF-BOF, whose output contracts by 21.8%, compared with only a 1.0% decline for EAF. Although total emissions fall by 18.0% and the EAF share of production rises, these changes reflect contraction of the carbon-intensive segment rather than expansion of cleaner technologies. The sector appears "cleaner," but only because it has become smaller.

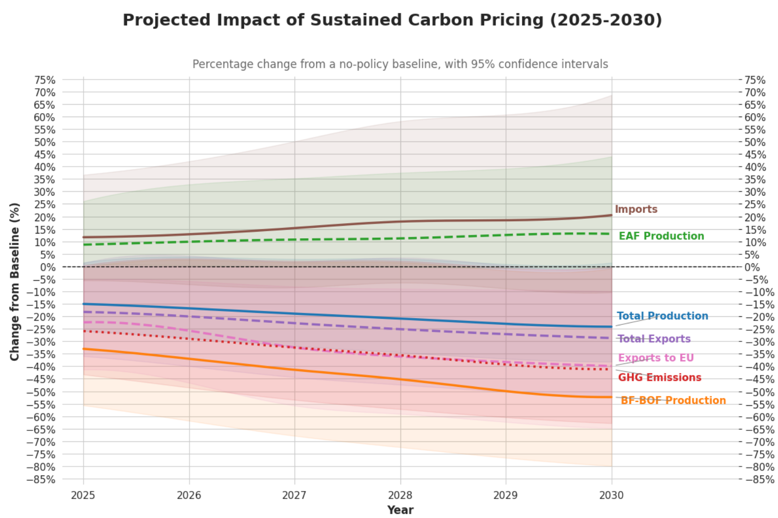

Figure 3: Projected Impact of Sustained Carbon Pricing (2025–2030). Percentage change from the no-policy baseline, with 95% confidence intervals.

Table 4: Simulated Impacts: Carbon Tax Maintained (CBAM-only)

Metric	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
— *Production & Domestic Market* —						
Total Production (Mt)	11.65 [-7.3%]	11.51 [-8.4%]	11.36 [-9.6%]	11.21 [-10.7%]	11.07 [-11.9%]	10.95 [-12.8%]
- BF-BOF (Mt)	6.26 [-12.4%]	6.13 [-14.3%]	5.99 [-16.3%]	5.85 [-18.2%]	5.70 [-20.3%]	5.59 [-21.8%]
- EAF (Mt)	5.38 [-0.6%]	5.38 [-0.7%]	5.37 [-0.7%]	5.37 [-0.9%]	5.37 [-0.9%]	5.36 [-1.0%]
Domestic Consumption of Domestic Steel (Mt)	5.94 [-5.7%]	5.88 [-6.6%]	5.82 [-7.5%]	5.76 [-8.5%]	5.70 [-9.5%]	5.65 [-10.2%]
Imports (Mt)	8.89 [+3.2%]	8.93 [+3.6%]	8.97 [+4.2%]	9.02 [+4.8%]	9.06 [+5.2%]	9.10 [+5.7%]
— *Trade* —						
Total Exports (Mt)	5.70 [-9.1%]	5.62 [-10.3%]	5.53 [-11.8%]	5.44 [-13.2%]	5.35 [-14.6%]	5.28 [-15.7%]
- to EU (Mt)	0.01 [-9.0%]	0.01 [-13.6%]	0.01 [-18.0%]	0.01 [-22.3%]	0.01 [-25.9%]	0.01 [-27.8%]
- to USA (Mt)	5.11 [-9.1%]	5.04 [-10.3%]	4.96 [-11.7%]	4.88 [-13.1%]	4.80 [-14.6%]	4.74 [-15.7%]
- to ROW (Mt)	0.57 [-9.1%]	0.56 [-10.3%]	0.55 [-11.7%]	0.55 [-13.1%]	0.54 [-14.6%]	0.53 [-15.7%]
— *Environmental & Fiscal Outcomes* —						
Total Emissions (Mt CO_2)	10.94 [-10.2%]	10.75 [-11.8%]	10.55 [-13.4%]	10.36 [-15.0%]	10.15 [-16.7%]	10.00 [-18.0%]
CBAM Payments (Million USD)	0.0	0.1	0.2	0.3	0.4	0.5
Domestic Carbon Revenue (Million USD)	69.1	78.5	87.4	95.9	103.8	111.8

5.2. Scenario 2: A Fragile "Growth-Led" Alternative (BCA without Retaliation)

A domestic BCA implemented from 2026 is the only pathway that supports growth-led decarbonization. Imports fall by 23.2% by 2030, allowing Canadian producers to regain domestic market share and limiting the total production decline to -6.3% (Table 5). Most importantly, EAF production expands by 6.0% in absolute terms, marking a genuine technological shift. This scenario demonstrates that BCAs can foster proactive upgrading, but only under conditions free from geopolitical retaliation.

5.3. Scenario 3: Geopolitical Risk and the Collapse of a Growth-Led Pathway (BCA with U.S. Retaliation)

Introducing a 25% retaliatory U.S. tariff fundamentally alters the outcome. Export demand collapses, with U.S.-bound exports declining by 59.4% (Table 6), producing an overall 14.0% fall in total production by 2030—an even worse outcome than the Status Quo. This scenario yields the largest emissions reduction (-19.1%) and the highest EAF share. Yet in absolute terms, EAF output falls by 2.2%. The apparent progress is thus a statistical artifact of industrial contraction: emissions decline because the industry shrinks, not because clean technology grows.

Table 5: Simulated Impacts: Carbon Tax Maintained + BCA (No Retaliation)

Metric	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
— *Production & Domestic Market* —						
Total Production (Mt)	11.64 [-7.4%]	12.02 [-4.3%]	11.94 [-5.0%]	11.89 [-5.3%]	11.83 [-5.8%]	11.77 [-6.3%]
- BF-BOF (Mt)	6.25 [-12.5%]	6.41 [-10.3%]	6.31 [-11.8%]	6.22 [-12.9%]	6.13 [-14.3%]	6.03 [-15.6%]
- EAF (Mt)	5.38 [-0.6%]	5.61 [+3.6%]	5.63 [+4.1%]	5.67 [+4.7%]	5.70 [+5.3%]	5.74 [+6.0%]
Domestic Consumption of Domestic Steel (Mt)	5.94 [-5.7%]	6.88 [+9.2%]	6.94 [+10.1%]	7.01 [+11.4%]	7.09 [+12.5%]	7.15 [+13.5%]
Imports (Mt)	8.89 [+3.2%]	7.25 [-15.8%]	7.11 [-17.4%]	6.94 [-19.5%]	6.77 [-21.4%]	6.61 [-23.2%]
— *Trade* —						
Total Exports (Mt)	5.70 [-9.0%]	5.10 [-18.6%]	4.96 [-20.9%]	4.82 [-23.1%]	4.67 [-25.5%]	4.54 [-27.6%]
- to EU (Mt)	0.01 [-8.9%]	0.01 [-25.1%]	0.01 [-30.3%]	0.01 [-34.8%]	0.01 [-39.3%]	0.01 [-42.1%]
- to USA (Mt)	5.12 [-9.0%]	4.58 [-18.6%]	4.45 [-20.9%]	4.33 [-23.0%]	4.19 [-25.4%]	4.08 [-27.5%]
- to ROW (Mt)	0.57 [-9.0%]	0.51 [-18.6%]	0.50 [-20.9%]	0.48 [-23.0%]	0.47 [-25.4%]	0.46 [-27.5%]
— *Environmental & Fiscal Outcomes* —						
Total Emissions (Mt CO_2)	10.94 [-10.3%]	11.24 [-7.8%]	11.11 [-8.9%]	11.01 [-9.7%]	10.89 [-10.6%]	10.77 [-11.6%]
CBAM Payments (Million USD)	0.0	0.0	0.0	0.0	0.0	0.0
Domestic Carbon Revenue (Million USD)	69.1	81.3	91.0	100.9	110.6	120.3
BCA Revenue (Million USD)	0.0	904.7	1013.2	1122.8	1226.7	1327.6

Table 6: Simulated Impacts: Carbon Tax Maintained + BCA (with 25% U.S. Retaliation Tariff)

Metric	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
— *Production & Domestic Market* —						
Total Production (Mt)	11.64 [-7.4%]	10.97 [-12.7%]	10.92 [-13.1%]	10.90 [-13.3%]	10.87 [-13.5%]	10.80 [-14.0%]
- BF-BOF (Mt)	6.25 [-12.5%]	5.82 [-18.7%]	5.73 [-19.8%]	5.67 [-20.7%]	5.60 [-21.6%]	5.51 [-23.0%]
- EAF (Mt)	5.38 [-0.6%]	5.15 [-4.9%]	5.19 [-4.2%]	5.23 [-3.5%]	5.26 [-2.8%]	5.30 [-2.2%]
Domestic Consumption of Domestic Steel (Mt)	5.94 [-5.7%]	7.59 [+20.5%]	7.65 [+21.4%]	7.70 [+22.2%]	7.74 [+23.0%]	7.78 [+23.5%]
Imports (Mt)	8.89 [+3.2%]	6.75 [-21.6%]	6.60 [-23.3%]	6.44 [-25.2%]	6.29 [-27.0%]	6.15 [-28.6%]
— *Trade* —						
Total Exports (Mt)	5.70 [-9.1%]	3.27 [-47.9%]	3.15 [-49.8%]	3.05 [-51.2%]	2.96 [-52.7%]	2.85 [-54.6%]
- to EU (Mt)	0.01 [-9.0%]	0.01 [-8.5%]	0.01 [-15.6%]	0.01 [-21.5%]	0.01 [-27.1%]	0.01 [-31.1%]
- to USA (Mt)	5.11 [-9.1%]	2.62 [-53.4%]	2.52 [-55.1%]	2.45 [-56.4%]	2.38 [-57.6%]	2.29 [-59.4%]
- to ROW (Mt)	0.57 [-9.1%]	0.63 [+0.3%]	0.61 [-3.1%]	0.59 [-5.9%]	0.57 [-9.3%]	0.55 [-12.0%]
— *Environmental & Fiscal Outcomes* —						
Total Emissions (Mt CO_2)	10.93 [-10.3%]	10.22 [-16.1%]	10.12 [-16.9%]	10.06 [-17.5%]	9.98 [-18.1%]	9.86 [-19.1%]
CBAM Payments (Million USD)	0.0	0.0	0.0	0.0	0.0	0.0
Domestic Carbon Revenue (Million USD)	69.1	78.5	87.4	95.9	103.8	111.8
BCA Revenue (Million USD)	0.0	842.2	940.9	1042.7	1140.7	1233.8

5.4. Scenario 4: The Cost of Inaction (Carbon Tax Repeal)

The repeal of the carbon tax from 2027 illustrates the trade-off between short-term competitiveness and long-term climate ambition. Production and emissions rebound immediately to baseline levels (Figure 4, dashed-dotted orange line; Table 7). However, all progress in emissions reduction is lost, the EAF share stagnates at 43.1%, and domestic carbon revenues disappear. Canada also forfeits fiscal sovereignty, as CBAM payments to the EU rise more than tenfold relative to the Status Quo. This pathway preserves industrial activity at the cost of climate objectives and technological upgrading.

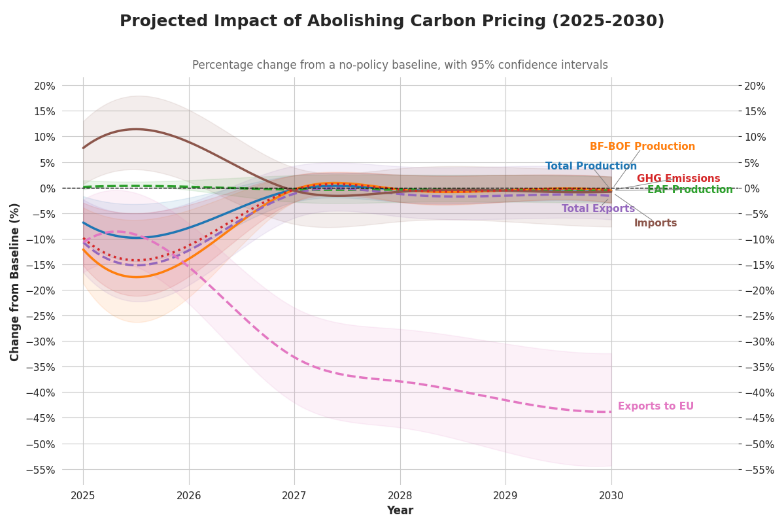

Figure 4: Projected Impact of Abolishing Carbon Pricing (2025–2030). Percentage change from a no-policy baseline, with 95% confidence intervals.

Table 7: Simulated Impacts: Carbon Tax Repealed from 2027 (CBAM-only)

Metric	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
— *Production & Domestic Market* —						
Total Production (Mt)	11.65 [-7.2%]	11.51 [-8.4%]	12.56 [-0.0%]	12.56 [-0.0%]	12.56 [-0.0%]	12.56 [-0.0%]
- BF-BOF (Mt)	6.27 [-12.3%]	6.13 [-14.2%]	7.15 [-0.0%]	7.15 [-0.0%]	7.15 [-0.0%]	7.15 [-0.0%]
- EAF (Mt)	5.38 [-0.6%]	5.38 [-0.7%]	5.41 [-0.0%]	5.41 [-0.0%]	5.41 [-0.0%]	5.41 [-0.0%]
Domestic Consumption of Domestic Steel (Mt)	5.94 [-5.6%]	5.88 [-6.6%]	6.30 [+0.0%]	6.30 [+0.0%]	6.30 [+0.0%]	6.30 [+0.0%]
Imports (Mt)	8.88 [+3.2%]	8.93 [+3.7%]	8.61 [-0.0%]	8.61 [-0.0%]	8.61 [-0.0%]	8.61 [-0.0%]
— *Trade* —						
Total Exports (Mt)	5.71 [-8.9%]	5.62 [-10.3%]	6.26 [-0.0%]	6.26 [-0.0%]	6.26 [-0.1%]	6.26 [-0.1%]
- to EU (Mt)	0.01 [-8.8%]	0.01 [-13.5%]	0.01 [-32.6%]	0.01 [-36.7%]	0.01 [-40.6%]	0.01 [-43.4%]
- to USA (Mt)	5.12 [-8.9%]	5.04 [-10.3%]	5.62 [+0.0%]	5.63 [+0.0%]	5.63 [+0.0%]	5.63 [+0.0%]
- to ROW (Mt)	0.57 [-8.9%]	0.56 [-10.3%]	0.63 [+0.0%]	0.63 [+0.0%]	0.63 [+0.0%]	0.63 [+0.0%]
— *Environmental & Fiscal Outcomes* —						
Total Emissions (Mt CO_2)	10.96 [-10.1%]	10.76 [-11.7%]	12.19 [-0.0%]	12.19 [-0.0%]	12.19 [-0.0%]	12.19 [-0.0%]
CBAM Payments (Million USD)	0.0	0.1	1.1	1.2	1.3	1.4
Domestic Carbon Revenue (Million USD)	69.2	78.5	0.0	0.0	0.0	0.0

6. Discussion

Our simulation results provide a nuanced perspective on the effectiveness of carbon pricing and border adjustments in advanced economies. The findings underscore the need to look beyond headline emission reductions and examine the quality of decarbonization. The contrast between “growth-led” and “recession-led” pathways represents the central insight of this study, with important implications for the design and evaluation of climate policy in mature industrial sectors.

6.1. The Two Faces of Decarbonization: Growth vs. Recession

The analysis shows that an increasing share of clean technology can be misleading. In both the Status Quo and the BCA with U.S. Retaliation scenarios, the Canadian steel sector appears “cleaner,” but this reflects contraction of BF-BOF capacity rather than expansion of EAF production. Such “recession-led” decarbonization is characterized by industrial decline, where carbon pricing primarily functions as a mechanism for phasing out high-emission assets rather than promoting new investment.

In contrast, the BCA without Retaliation scenario illustrates a “growth-led” pathway. A protected domestic market enables an absolute increase in EAF production, representing genuine technological upgrading. Yet the fragility of this outcome—its reversal under U.S. retaliation—highlights the dependence of positive-sum outcomes on international cooperation. Without alignment among key trading partners, the conditions for reconciling competitiveness with decarbonization remain precarious.

6.2. The Limits of “First-Generation” Climate Policy

The results challenge the assumption that steadily rising carbon prices alone can drive deep decarbonization. For advanced economies, carbon pricing and BCAs function as necessary but insufficient “first-generation” policies. Their strength lies in accelerating the retirement of carbon-intensive assets, effectively managing decline. However, they are poorly suited to catalyze the high-risk capital investments required for transformative technologies such as green hydrogen-based steelmaking. With the transition to EAF already well advanced, further progress demands investment far beyond what current pricing levels incentivize. Relying exclusively on these instruments risks pushing mature industries into a low-growth equilibrium where emissions targets are met through contraction rather than innovation.

6.3. Limitations and Directions for Future Research

Several limitations should be noted. First, the model assumes a uniform federal carbon tax, abstracting from provincial heterogeneity such as Quebec's cap-and-trade system. Future research could investigate how subnational variation shapes investment incentives. Second, emission intensity data are based on established benchmarks (Hasanbeigi et al., 2016) that predate recent technological improvements; incorporating updated, country-specific data would enhance accuracy. Finally, the analysis is limited to existing technologies. An important next step is to assess how "second-generation" promotional policies—such as capital subsidies for green hydrogen projects or carbon contracts for difference—could make near-zero emission technologies economically viable and enable truly growth-led deep decarbonization.

7. Conclusion and Policy Implications

This study examined the dilemma facing carbon-pricing advanced economies as they navigate the interaction of domestic climate policy, international trade mechanisms such as the EU's CBAM, and geopolitical realities. Using Canada's steel sector as a case study, we conclude that the effectiveness of climate policy should not be measured solely by emission reductions but by the quality of the underlying economic transition.

The central conclusion is that for mature industries in advanced economies, conventional "first-generation" policies such as carbon pricing and border adjustments are approaching their limits. While essential for penalizing pollution and managing the decline of legacy assets, these tools are insufficient to catalyze the transformative investments required for deep decarbonization. Over-reliance on them risks producing "recession-led" decarbonization, where climate goals are met through deindustrialization rather than innovation.

From this conclusion, three key policy implications emerge:

1. **Acknowledge the dual nature of policy tools.** Carbon pricing is effective for phasing out carbon-intensive production but weak in stimulating new investment. Its role in an industrial strategy is necessary but inherently limited.
2. **Embrace "second-generation" industrial policy.** To foster a "growth-led" transition, governments must complement carbon pricing with

proactive instruments. These include targeted investment tax credits, public procurement of green materials, and support for enabling infrastructure. Such policies are essential to de-risk and accelerate the deployment of next-generation clean technologies.

3. **Prioritize economic statecraft.** The fragility of the "growth-led" pathway shows that climate policy is inseparable from international relations. For economies like Canada, where industrial health is tied to partners following divergent policy paths, the effectiveness of measures such as a BCA depends less on technical design and more on securing cooperation with major partners—particularly the United States—to ensure a stable and predictable investment environment.

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