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U.S Border Carbon Adjustment for Steel and Aluminum

Author: Ali Hasanbeigi, PhD

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Executive Summary

The industry sector accounts for over one-third of global anthropogenic greenhouse gas (GHG) emissions. The steel and aluminum industry combined account for around 13% (steel, 11%, and aluminum, 2%) of global CO_2 emissions. The emissions from these heavy industries must be reduced sharply for the world to reach the target of the Paris Climate Agreement: to limit global warming to “well below” 2 ℃.

Approximately 24% of the total steel and 33% of the total unwrought aluminum and aluminum alloys produced globally is traded across borders. The U.S. imported around 25 million tonnes (Mt) of steel products, and 4.8 Mt of crude and semimanufactures aluminum from other countries, which accounts for a large share of steel and aluminum consumed in the U.S. Since carbon intensity of steel and aluminum production vary substantially between countries, the heterogeneous climate policies across countries risk intensifying carbon leakage as production continues to shift to countries with lower climate ambition or lesser-regulated countries.

The U.S. steel and aluminum industries have a substantial carbon advantage over many countries it is importing steel and aluminum. On average (including both primary and secondary processes), they emit lower CO_2 emissions to produce a tonne of steel and aluminum compared to many other countries. This carbon advantage should be leveraged to reward domestic cleaner steel and aluminum production and encourage the decarbonization of these two industries in other countries. Around 100% of steel and 66% of aluminum imported to the U.S. is from countries that have higher average CO_2 emissions intensity per tonne of steel and aluminum than that of the U.S. A carbon fee and border adjustment would unlock a competitive advantage for the U.S. steel and aluminum industry. Border Carbon Adjustment (BCA) is a policy tool for preventing carbon leakage as some countries, such as the U.S., are taking serious actions to tackle the climate crisis and achieve Paris Agreement’s target.

This study analyzes the production and trade of steel and aluminum in the U.S. and the carbon competitiveness of the U.S. steel and aluminum industry. We developed three different scenarios to assess the impact of a potential U.S. BCA on GHG emissions and revenue of the steel and aluminum industry in the U.S. up to 2030. The three scenarios are (See Section 5.1 for a more detailed explanation):

- Scenario 1: Average CO_2 intensity of steel/aluminum in each country is used (Has domestic CO_2 price)
- Scenario 2: Average CO_2 intensity of steel/aluminum used for developed countries and economy-wide intensity for developing countries (Has domestic CO_2 price)
- Scenario 3: Country-specific primary and secondary steel/aluminum CO_2 intensity are considered separately (Has domestic CO_2 price)

In these scenarios, the carbon levy on imports is applied to the difference between the CO_2 intensity of U.S. steel and aluminum production and the CO_2 intensity in countries the U.S. is importing steel and aluminum. These scenarios also include a carbon levy for domestic steel and aluminum producers in the U.S. whose CO_2 intensity is above the U.S. industry baseline.

We conducted this scenario analysis using three different carbon price levels (low, medium, and high). We then discuss policy design considerations for a BCA policy based on international practices and discuss the trade implications of a BCA policy.

Figure ES1 shows the total annual revenue of BCA for steel, aluminum, and steel contained in passenger cars. This includes import revenue plus net domestic revenue after the export rebate. The total annual revenue of BCA ranges from $578 million to $2,047 million for steel, $206 million to $1,084 million for aluminum, and $39 million to $280 million for steel contained in passenger cars in 2024. These annual revenues will substantially increase in 2030 as the price of carbon increases.

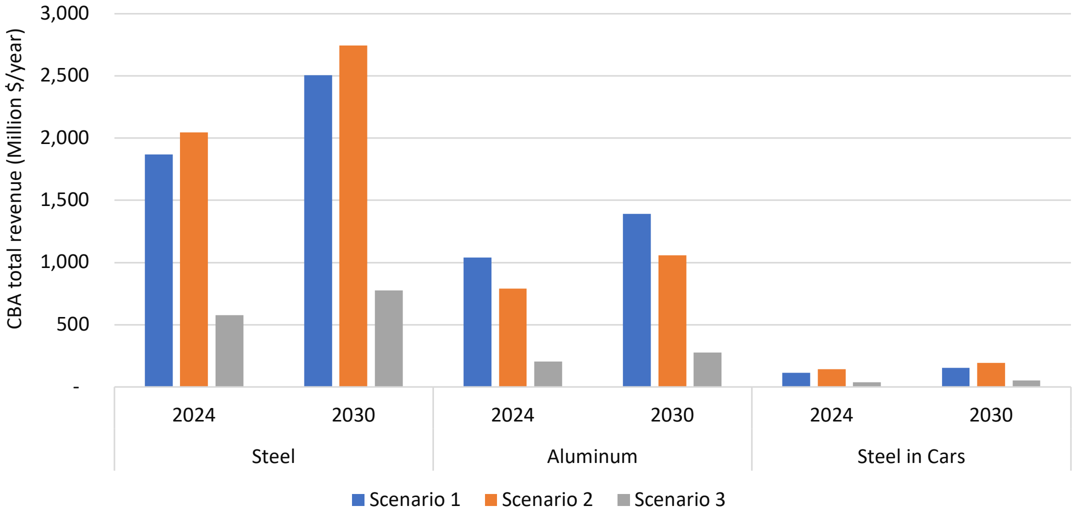

Figure ES1. Total annual revenue of BCA for steel, aluminum, and steel contained in passenger cars (import revenue plus net domestic revenue after export rebate) under MED carbon price (Million $/year)

Scenario 1: Average CO_2 intensity of steel/aluminum in each country is used (Has domestic CO_2 price)

Scenario 2: Average CO_2 intensity of steel/aluminum used for developed countries and economy-wide intensity for developing countries (Has domestic CO_2 price)

Scenario 3: Country-specific primary and secondary steel/aluminum CO_2 intensity are considered separately (Has domestic CO_2 price)

The reduction in imported steel as a result of U.S. BCA for steel under MED carbon price in Scenario 1 is equal to 26% in 2024 and 55% in 2030 of total imported steel in the U.S. (Figure ES2). This translates into a reduction in embodied carbon in imported steel equal to 15% in 2024 and 27% in 2030 of total embodied CO_2 in imported steel in the U.S. (Figure ES2). This is because the weighted average CO_2 intensity of steel production in the U.S. (primary and secondary) is substantially lower than that in most other countries from which it is importing steel. The increase in annual *revenue* of U.S. steel companies as a result of reduced U.S. imports is around $4,000 million in 2024 and $8,500 million in 2030. The results for the U.S. BCA for aluminum are also presented in Figure ES2.

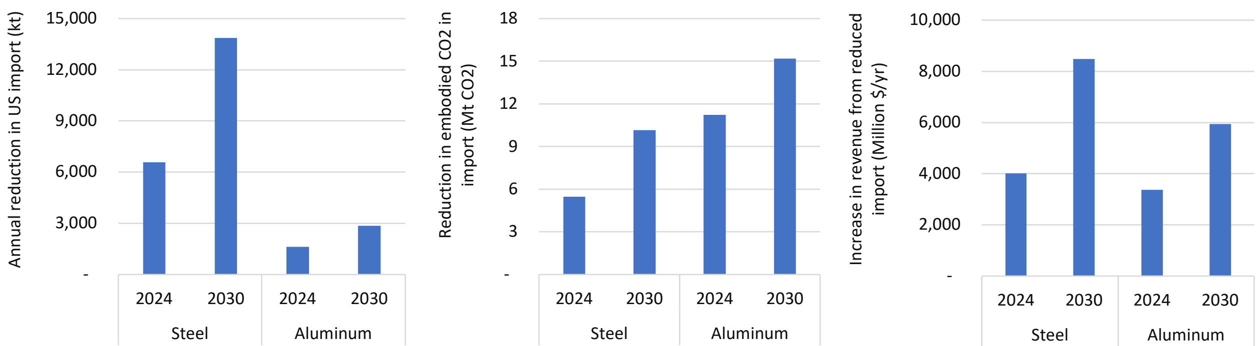

Figure ES2. Reduction in annual imports and their associated CO_2 and Increase in annual revenue of U.S. steel/aluminum companies as a result of U.S. BCA under MED carbon price in Scenario 1 .

The import carbon fee for steel contained per passenger car ($/car) is minimal compared with an average price of a passenger car in the U.S., and therefore it is highly unlikely that such a carbon fee will result in a reduction in cars imported to the U.S.

The increase in the U.S. steel and aluminum industry's annual revenue resulting from the reduced steel and aluminum import caused by U.S. BCA will be distributed across all regions in the U.S. For the steel industry, the steel plants in the Southern and Great Lakes region will benefit the most.

Our analysis shows that even if only 75% of the total revenue from a U.S. BCA for steel, aluminum, and steel contained in passenger cars is spent domestically (with the remaining 25% spent internationally to help decarbonize the industry sector in developing countries as proposed by Clean Competition Act by Senator Sheldon Whitehouse), it still will put substantially more money back into the U.S. industry than the carbon levy domestic producers will have to pay.

There are different policy design considerations when planning for a BCA policy. Some of the key policy components are identifying objectives, determining targets, establishing tax base and enforcement mechanisms, and measuring the impact on trade, carbon, and policy.

The Border Carbon Adjustment policy has serious implications for trade relationships/agreements involving both developing and developed countries. Its impact is associated with bilateral, multilateral, and WTO trade agreements. Introducing a BCA might change trade patterns in favor of countries with carbon-efficient production. However, if the carbon export rebate and import tax are equal to the domestic carbon tax in the BCA program, then the BCA is theoretically trade-neutral; thus, it does not encourage or discourage trade. Nonetheless, there is concern that implementing the BCA policy could lead to retaliatory tariffs or trade wars. To be successful, a BCA must be accompanied by multilateral and bilateral cooperation initiatives regarding climate mitigation and carbon emissions reduction. An example of this is the U.S.- EU Carbon-Based Sectoral Arrangement on Steel and Aluminum Trade.

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Introduction

The industry sector accounts for more than one-third of global anthropogenic greenhouse gas (GHG) emissions. There is a growing awareness that emissions from heavy industries such as steel, aluminum, cement, and chemical must be reduced sharply for the world to reach the target of the Paris Climate Agreement: to limit global warming to "well below" 2 ℃. As the world's largest economy and the 2nd largest greenhouse gas (GHG) emitting country, the U.S. can play an important role in achieving this target.

A substantial amount of GHG emissions from the industry sector can be attributed to the products that are produced for export. The embodied GHG emissions associated with the production of products that are ultimately traded across countries are referred to as the Carbon Loophole (Hasanbeigi and Darwili, 2022). These emissions are a growing issue for global efforts to decarbonize the industry sector. Embodied emissions in traded goods are not accounted for in the countries that import and consume those goods,[1] but if they were, the promising climate trends in some countries would be negated or reversed. Around 25% of global CO_2 emissions are embodied in exported goods, thus escaping attribution in the consuming country (the end-user) and instead being debited at the producer side (Hasanbeigi and Darwili 2022).

Many large countries like the U.S. and China have a significant imbalance in the import or export of embodied emissions. China is the top exporter, while the U.S. is the top importer of embodied carbon in traded products in the world. The eclipsing of Western manufacturing by Chinese manufacturing, combined with the relative carbon intensity of the Chinese energy system, means that China has been a prime actor in the rise of carbon leakage and emissions displacement. Much of the apparent emissions reductions occurring in North America and Europe have been a shifting of emissions from these countries into China (Hasanbeigi and Darwili, 2022).

Approximately 24% of the total steel produced globally is traded across borders (this is steel mills products and does not include steel contained in final consumer products) (worldsteel 2022). In addition, around 33% of total unwrought aluminum and aluminum alloys produced globally are traded across borders in 2021 (USGS 2022, Statista 2022a). The U.S. imported around 25 Mt of steel products and 4.8 Mt of crude and semimanufactures aluminum from other countries (USGS 2022a, b). Since the carbon intensity of production of products such as steel and aluminum varies substantially between countries, as new climate policies emerge, the carbon loophole could be widened further. The heterogeneous climate policies risk intensifying carbon leakage as production continues to shift to countries with lower climate ambitions or fewer regulations.

The United States government has a target of reducing emissions by 50%–52% below 2005 levels by 2030 and, as a part of the Paris Agreement, pledged to reach net zero emissions economy-wide by no later than 2050. The U.S. also has set a goal to reach 100% CO_2-free electricity by 2035, which will substantially help the deep decarbonization of industries such as steel and aluminum (The White House 2021a). The Inflation Reduction Act signed into law by President Biden in August 2022 includes $369 billion to address climate change.

1 For example, countries only report their domestic carbon emissions (also known as production-based or territorial accounting) to the Intergovernmental Panel on Climate Change (IPCC).

Border Carbon Adjustment (BCA) is a policy tool for closing the carbon loophole at national borders and preventing carbon leakage as some countries are taking serious actions to tackle the climate crisis and achieve Paris Agreement's target (see below for more information on BCA).

This report focuses on two carbon-intensive materials in particular: steel and aluminum. These two sectors combined account for around 13% (steel, 11%, and aluminum, 2%) of global CO_2 emissions (Hasanbeigi 2022, Hasanbeigi et al. 2022). They are also covered by the EU's proposed Carbon Border Adjustment Mechanism (CBAM).

This report analyzes the production and trade of steel and aluminum in the U.S. and the carbon competitiveness of the U.S. steel and aluminum industry. We developed three different scenarios to assess the impact of a potential U.S. Border Carbon Adjustment (BCA) on GHG emissions and revenue of the steel and aluminum industry in the U.S. We conducted this scenario analysis using three different carbon price levels (low, medium, and high). We then discuss policy design considerations for a BCA policy based on international practices and also discuss the trade implications of a BCA policy.

1.1. What is a Border Carbon Adjustment (BCA)?

A Border Carbon Adjustment (BCA) is a policy used to equate the consumer cost for importers and exporters complying with carbon pricing in a country. By functioning as an additional fee on imports or a rebate on exports, a government can promote domestic competitiveness amongst carbon-intensive goods while enforcing compliance with set emissions levels (Pomerleau, 2020). The primary goal of a Border Carbon Adjustment is to minimize carbon leakage to the maximum extent possible; Carbon leakage is defined as an increase in foreign carbon emissions in response to domestic climate measures. It is calculated as a ratio of an increase in foreign emissions relative to a decrease in domestic emissions. When a country sets a carbon price on domestic manufacturing and production that companies must abide by, this comes with higher costs compared to foreign countries without such a carbon price. Thus, a Border Carbon Adjustment seeks to charge foreign producers for their ability to produce without compliance with the carbon price or having to pay a lower carbon price in their home country.

A BCA could be justified so long as the carbon fee imposed on imports and domestic products are equal. A BCA would function similarly to existing value-added taxes on goods coming into a country, levying a cost on consumption. A BCA is critical when considering a domestic carbon tax on emissions. If a government imposes a cost on carbon without coupling a border adjustment, domestic producers have a higher incentive to outsource their production to countries with cheaper labor, fewer requirements, and cheaper materials (Pomerleau, 2020). This would harm not only the domestic economy, costing jobs and tax revenue, but also contribute to GHG emissions globally. When considering climate change-conscious policies moving forward towards a net-zero future, a BCA is a sensible way to enforce compliance without jeopardizing domestic production.

As it is a highly sensitive and complex facet of international trade, there are several components of a BCA that policymakers need to consider. For a BCA to be successful, it must be accurately targeted to reduce leakage yet not be overly protectionist to discourage imports. A BCA would apply to specific eligible carbon-intensive goods subject to a carbon price domestically and imported into the country. Though many countries are aware of carbon emissions from domestic production due to reporting requirements, this is not the case for foreign entities, somewhat complicating the implementation of a BCA. Due to the various emissions policies unique to every country, policymakers must consider whether to apply this carbon fee equally to imports across the board or only to countries without carbon standards. Furthermore, it is critical to exhibit transparency throughout the drafting and implementation process to keep foreign stakeholders and governments in tune with any potential changes (Cosbey, 2021). These steps are vital to maintaining current levels of economic prosperity while ensuring domestic competitiveness.

A critical equity component of a BCA proposal is to what extent it will negatively impact developing countries throughout the world. As was the case for modern superpowers developing at the height of the Industrial Revolution two centuries ago, countries in development today rely heavily on the abundance and low-cost fossil fuels (without taking into account the environmental and health cost). The imposition of aggressive taxes on their production could effectively exclude them from international markets if the prices are too high, inhibiting their ability to reach international standards of human and economic development. Many still-developing nations in the Global South may not be able to fully compete or comply with such a policy for quite some time.

1.2. What are countries doing on Carbon Border Adjustment?

Despite a BCA being a relatively modern phenomenon, countries are quickly lining up to adjust their tax codes to regulate emissions-intensive industries. Most notable of these are the nations making up the European Union, with many of the member nations setting highly ambitious climate goals. In May 2022, the European Council officially accepted a framework for a Carbon Border Adjustment Mechanism (CBAM) seeking to reduce their leakage on imports, specifically targeting fertilizers, steel, iron, cement, aluminum, and electric energy production (Council of the EU, 2022). The trialogue process is now ongoing among the European Council, the European Commission, and the EU Parliament.

Though there has been some political infighting on the issue, the EU plans to put its CBAM into effect sometime in 2023 (Bray & Muresianu, 2022). The Union has set a high bar for its decarbonization goals and now passes this goal along to those seeking to do business inside their borders. Under the current framework, EU companies that are importing a good into the EU must purchase emissions credits to cover the level of emissions of the imported goods (Melin et al., 2021).

The consideration of an EU CBAM would heavily affect countries without a carbon tax, such as the longtime political and economic ally of the United States. While the United States has lagged behind Europe for some time in its climate ambitions, there are several pieces of potential legislation being considered that could bring the country up to speed. The most recent of these is the Clean Competition Act, introduced in June 2022 by Senator Sheldon Whitehouse (Office of Senator Sheldon Whitehouse, 2022). The seven proposals that include border adjustment provisions are shown in Table 1. In addition, In August of 2022, the Inflation Reduction Act (IRA) was signed into law, includes $369 billion to address climate change. The IRA has several components that can support future BCA policy in the U.S. It allocates over US$250 million to support the development, standardization, transparency, and reporting criteria for environmental product declarations (EPDs); US$100 million to support the development of a low-embodied carbon label for construction materials; and US$5 billion to purchase low-carbon materials for the construction of federal buildings, roads, bridges, and homes (H.R.5376 - 117th Congress 2022). Also, in September 2022, the Biden-Harris Administration announced new actions under its Federal Buy Clean Initiative to spur the development of low-carbon construction materials made in America (The White House 2022).

Table 1. Carbon border adjustments in congressional proposals (Kardish et al. 2022)

Proposal	Pricing option	Product coverage	Scope of emissions	Reciprocity
America's Clean Future Fund Act (S. 685 and H.R. 2451).	Explicit price	Fossil fuels and specialized products are determined to be EITE.	Emissions from "any inputs or processes used in manufacturing such [carbon-intensive] product" would be subject to domestic carbon fees. Emissions from the "use, sale, or transfer of [covered] fuel" would be subject to domestic carbon fees. Exact accounting is to be determined through rulemaking.	Foreign credit
Energy Innovation and Carbon Dividend Act of 2021 (H.R. 2307)	Explicit price	Fossil fuels and specified products determined to be EITE.	Emissions "accumulated upon the GHG content of the imported carbon-intensive product" had it been manufactured domestically and subject to a domestic carbon fee. Emissions from "fuel's GHG content under the domestic carbon fee, including processing emissions." Exact accounting is to be determined through rulemaking.	Foreign credit
MARKET CHOICE Act (H.R. 3039)	Explicit price	Products meeting GHG intensity & trade intensity metrics.	Equivalent to the carbon tax of comparable domestically manufactured goods. Exact accounting is to be determined through rulemaking.	Not specified
America Wins Act (H.R. 3311)	Explicit price	Specified products.	Equivalent to the carbon tax of comparable domestically manufactured goods. Exact accounting is to be determined through rulemaking.	Foreign credit
Save our Future Act (S. 2085)	Explicit price	Products meeting energy-intensity metrics.	Equivalent to the amount of the carbon fees imposed if a good was manufactured domestically multiplied by the average economy-wide carbon intensity metric. Firm-specific carbon intensity metrics could be used instead where reliable data is available. Exact accounting is to be determined through rulemaking.	Foreign credit
FAIR Transition and Competition Act (S. 2378 and H.R. 4534)	Implicit price	Fossil fuels and specified products.	Emissions from "production, manufacture, or assembly of a product." Emissions from the "extraction, processing, transportation, financing, or other preparation of a covered fuel for use." Benchmark annual average emissions from domestic industrial sectors with reliable data. Exact accounting is to be determined through rulemaking.	None
Clean Competition Act (S. 4355)	Benchmark price	Specified products meeting carbon intensity metrics.	Emissions are associated with the production of covered primary goods and from electricity used for the production of such goods. Exact accounting is to be determined through rulemaking.	None

Without a border carbon fee, the United States could face a significant loss if a domestic carbon price is introduced since a substantial share of its domestic production, especially steel and aluminum, has significantly lower carbon intensity than international competitors.

The Clean Competition Act aims to impose a BCA in the U.S. beginning in 2024 on several carbon-intensive goods, many of which are covered by the EU's CBAM, including "fossil fuels, refined petroleum products, petrochemicals, fertilizer, hydrogen, adipic acid, cement, iron and steel, aluminum, glass, pulp and paper, and ethanol." Pricing would be based on calculations of the origin country's average economy-wide emissions or, if auditable data exists, industry-specific data on carbon intensity (Office of Senator Sheldon Whitehouse, 2022). Though this proposal would be a step in the right direction for the United States, critics claim it is not broad enough in scope, and it is unknown if there is enough bipartisan support to create the law. There are, however, several Republican lawmakers that have a strong interest in a U.S. BCA policy.

Both Canada and the United Kingdom are currently in talks to implement a similar BCA policy as well. Both aspire to be as ambitious as the EU in combating climate change and have begun following their path toward a BCA. In Canada, as the price of carbon continues increasing over time up to $170/tonne CO_2 in 2030, the country is considering rewarding its domestic producers with a BCA. As for the United Kingdom, a parliamentary inquiry has called for the country to explore the possibility of a BCA (Leith et al., n.d.). As is the case with the United States and Canada, the new deliberations on BCA provide a tremendous opportunity for multilateral collaboration on an international standard. If these countries can closely align with EU CBAM policy, which will be the first enacted globally, perhaps this could influence other nations to follow suit.

2 Production and trade

2.1. Global steel production and trade

World steel production has more than doubled between 2000 and 2021 (Figure 1). In 2021, China accounted for 53% of global steel production, while its share was only 15% in 2000. The 2008 drop in world steel production was because of the global economic recession. The 2021 decline in China's crude steel production could be the result of both the COVID-19 pandemic as well as Chinese Government's policy to reduce the total steel production in 2021 compared to the previous year.

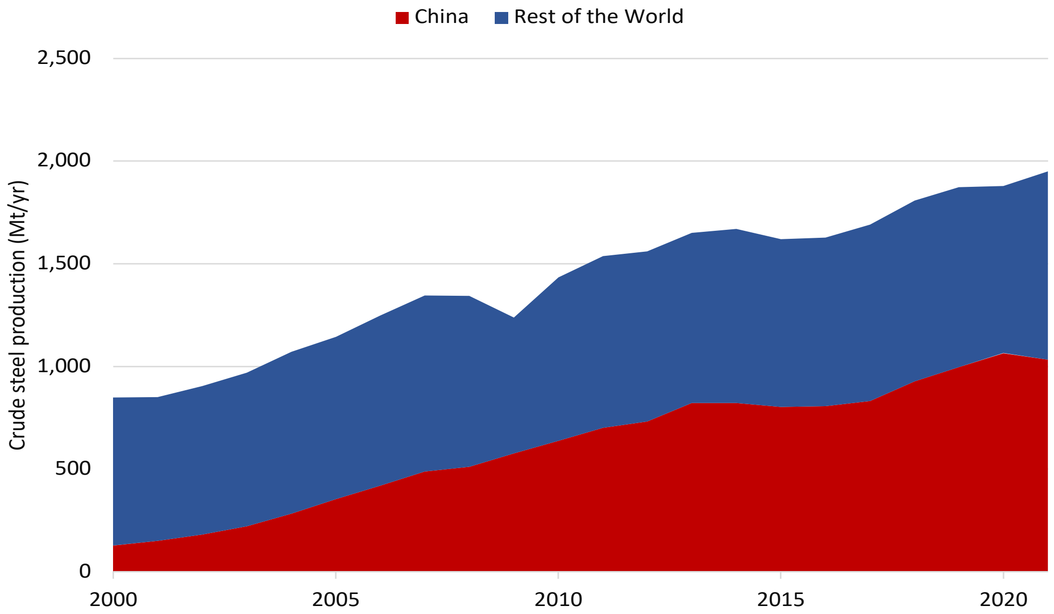


Figure 1. Crude steel production in China and the rest of the world, 2000-2021 (Worldsteel 2021, 2022).

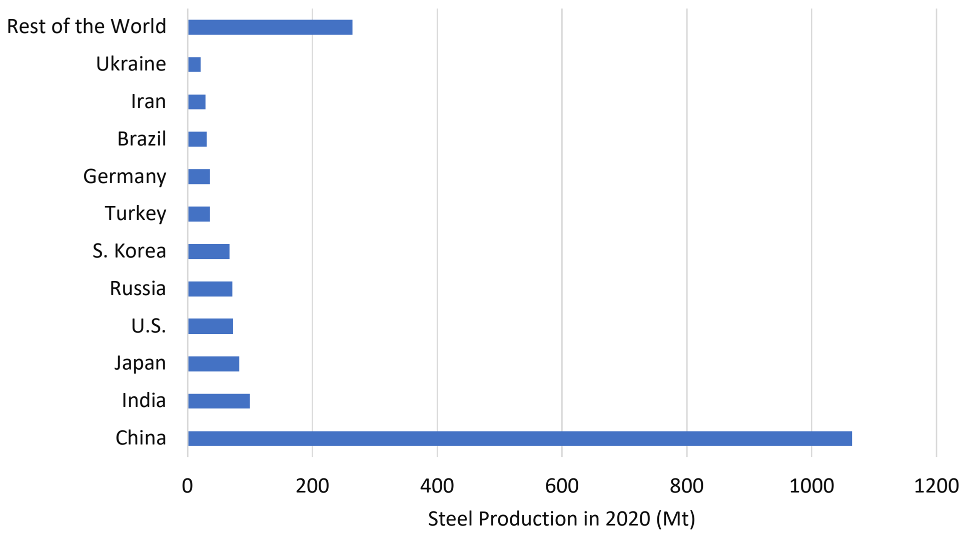


Figure 2. shows the top 10 steel-producing countries in the world. In 2021, these top 10 producing countries accounted for 83% of world steel production (Worldsteel 2022).

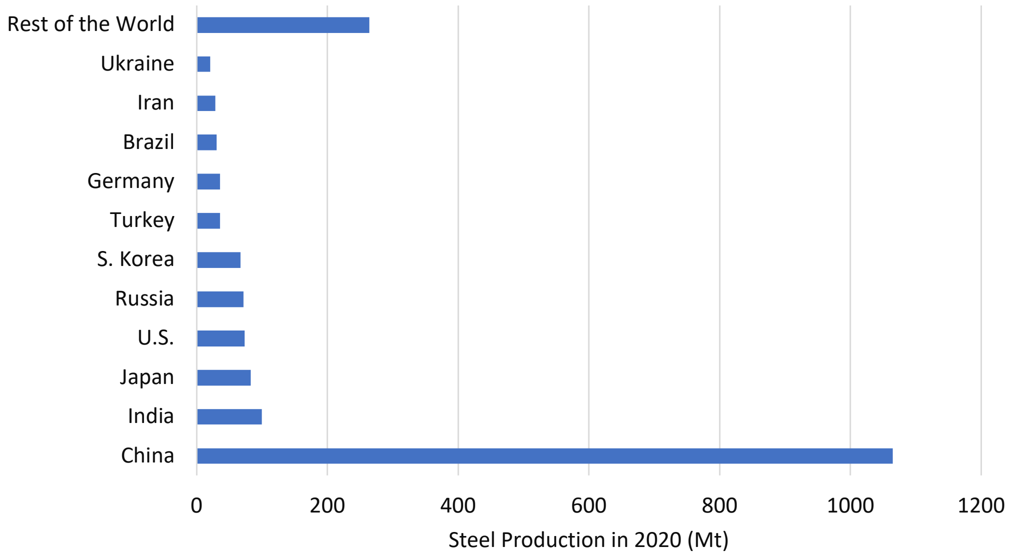


Figure 2. Top 10 steel-producing countries in 2021 (Worldsteel 2021) .

The top 20 exporting countries account for over 90% of total world steel exports. According to Worldsteel (2022), China, Japan, Russia, South Korea and EU27 are the top five exporters, and the EU27, U.S., China, Germany, and Italy are the top five importers of steel in 2021 (Table 2). China's export alone is larger than the entire crude steel production in Turkey, which is the 7th largest steel producer in the world. The significant global trade of such a carbon-intensive commodity has substantial implications for the embodied carbon in traded steel, as shown in our recent study (Hasanbeigi and Darwili, 2022). This embodied carbon in traded steel often is not accounted for in national and international carbon accounting and climate policies.

Table 2. Top 20 exporters and importers of steel in 2021 (Worldsteel 2022)

Rank	Total exports	Mt
1	China	66.2
2	Japan	33.8
3	Russia	32.6
4	South Korea	26.8
5	European Union (27) [1]	26.0
6	Germany [2]	23.9
7	Turkey	22.1
8	India	20.4
9	Italy [2]	17.2
10	Ukraine	15.7
11	Belgium [2]	15.5
12	France [2]	12.6
13	Brazil	11.5
14	Vietnam	11.2
15	Taiwan, China	10.8
16	Netherlands [2]	10.1
17	Indonesia	9.9
18	Spain [2]	9.7
19	Malaysia	8.3
20	United States	8.2

Rank	Total imports	Mt
1	European Union (27) [1]	48.1
2	United States	29.7
3	China	27.8
4	Germany [2]	23.3
5	Italy [2]	20.8
6	Turkey	16.2
7	Thailand	15.7
8	Mexico	15.1
9	South Korea	14.1
10	Poland [2]	13.7
11	Belgium [2]	13.7
12	France [2]	13.3
13	Vietnam	13.0
14	Netherlands [2]	10.5
15	Indonesia	10.2
16	Spain [2]	10.1
17	Canada	9.9
18	Taiwan, China	9.6
19	Czechia [2]	8.5
20	Philippines	7.2

(1) Excluding intra-regional trade

(2) Data for individual European Union (27) countries include intra-European trade

2.2. U.S. steel production and trade

The U.S. iron and steel industry produced raw steel in 2021 with an estimated value of about $110 billion, a 21% increase from $91 billion in 2020. Pig iron and raw steel were produced by three companies operating integrated steel mills in 11 locations. Raw steel was produced by 50 companies at 101 minimills. The combined production capacity was about 106 million tons. Indiana accounted for an estimated 27% of total raw steel production, followed by Ohio, 11%; Pennsylvania, 5%; Illinois and Texas, 4% each; and Michigan, 3%, with no other State having more than 3% of total domestic raw steel production. Construction accounted for an estimated 47% of total domestic shipments by market classification, followed by transportation (predominantly automotive), 25%. In 2021, iron and steel mills in the U.S. employed around 86,000 people, while steel product manufacturing employed an additional 56,000 people (USGS 2022a).

Primary steelmaking using iron ore via blast furnace and basic oxygen furnace (BF-BOF) process and secondary steelmaking using steel scrap in electric arc furnace (EAF) production routes are the most common steelmaking process routes today. Overall, steel production has been declining in the U.S. in the past two decades (Figure 3). The production in 2021 is back up to the 2019 level after a sudden drop in 2020 because of the global COVID-19 pandemic.

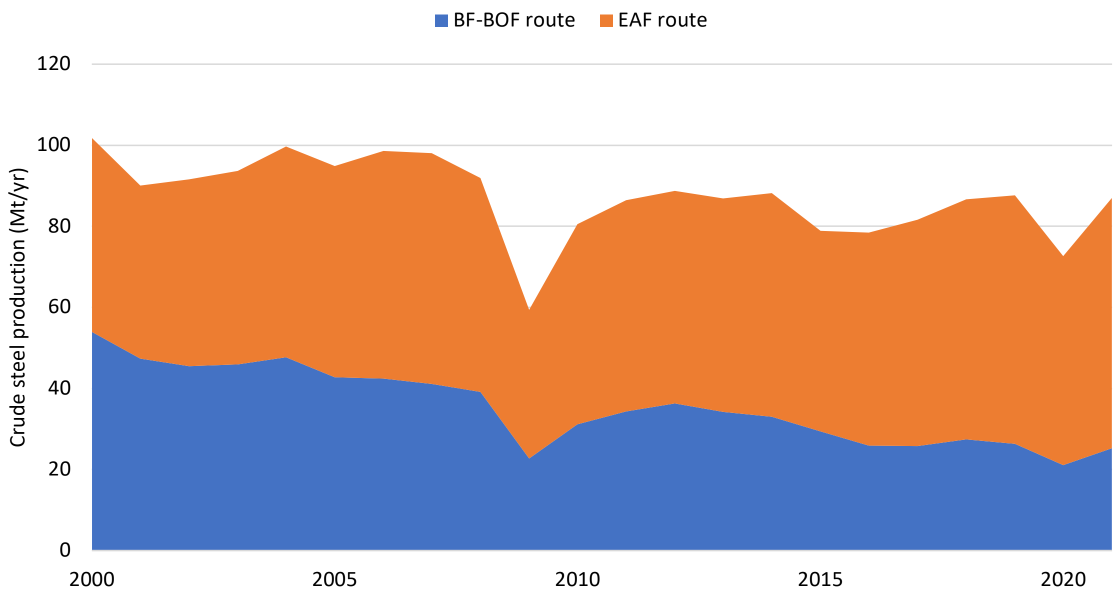


Figure 3. Crude steel production in the U.S. by production routes, 2000-2021 (USGS, various years).

The U.S. imported around 25 Mt and exported around 8.3 Mt of finished and semi-finished steel products in 2021 (USGS 2022a). Figure 4 shows the top countries where the U.S. imported steel in 2019. Canada was the top exporter of steel to the U.S. (20% of total U.S. imports), followed by Brazil (15%), Mexico (13%), and South Korea (9%).

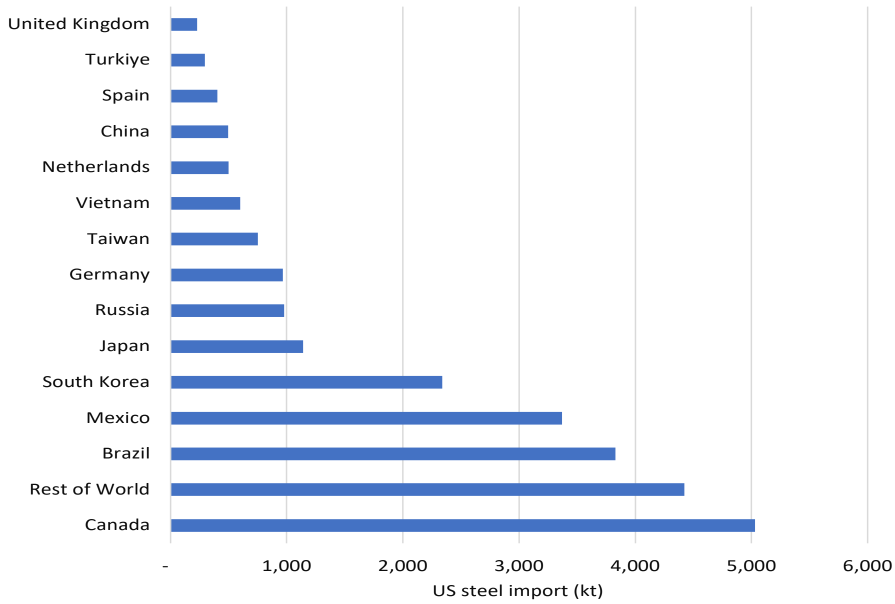


Figure 4. U.S. import of steel products in 2019 by country of origin (USGS 2022).

Figure 5 shows the top countries that the U.S. exported steel in 2019. Mexico and Canada together account for 90% of the U.S. steel export. Other individual countries account for less than 1% of the U.S. steel export.

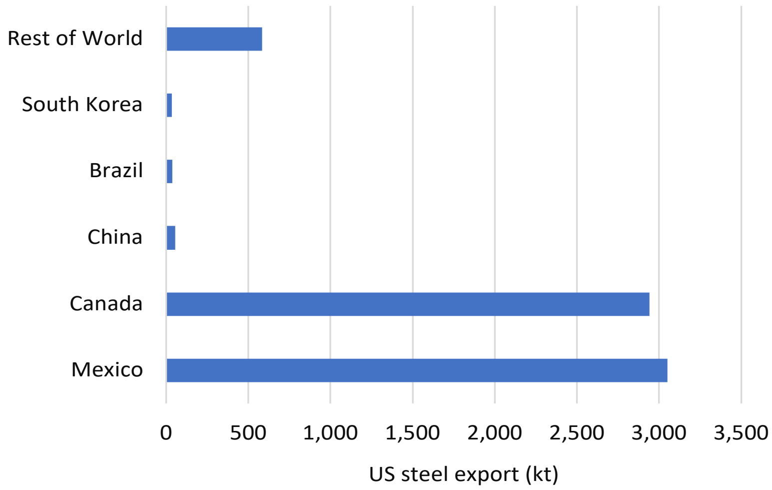


Figure 5. U.S. export of steel products in 2019 by country of destination (USGS 2022) .

2.3. Global aluminum production and trade

World aluminum production has more than doubled between 2000 and 2021 (Figure 6). In 2020, China accounted for 57 percent of global aluminum production, while its share was only 11 percent in 2000. The 2008 drop in world aluminum production was because of the global economic recession.

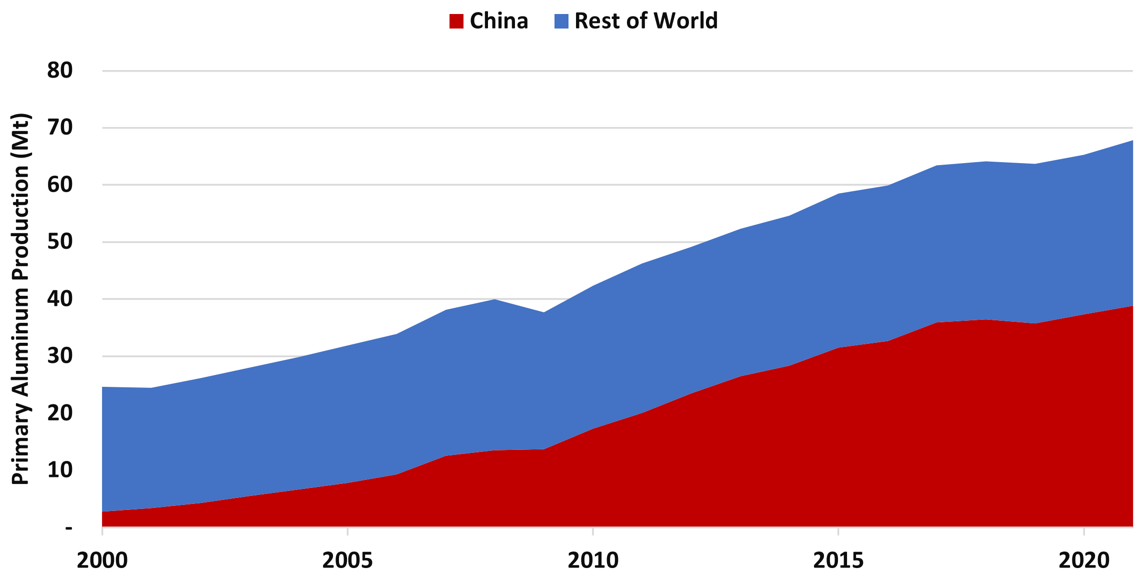


Figure 6. Primary aluminum production in China and the rest of the world, 2000-2021 (IAI 2022).

Figure 7 shows the top 10 aluminum-producing countries in the world. In 2019, these top 10 producing countries accounted for 86 percent of world aluminum production (USGS 2022b).

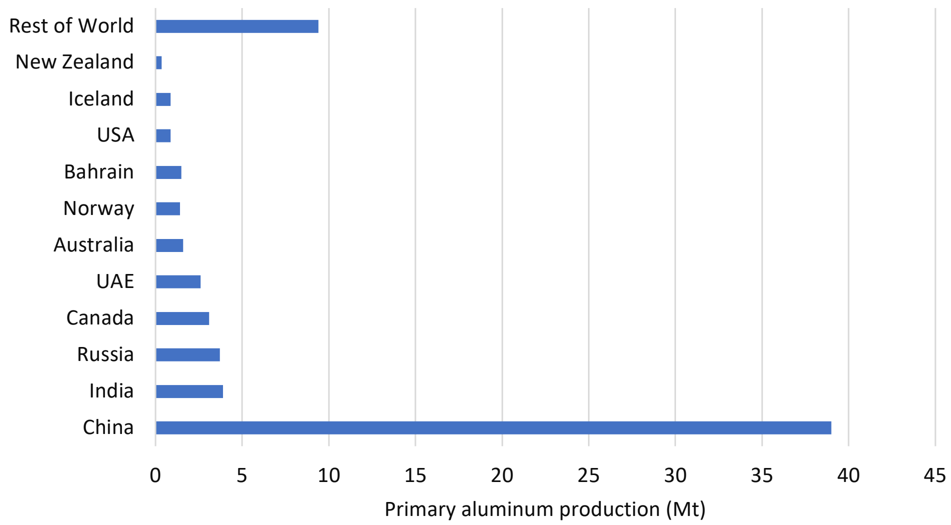


Figure 7. Top 10 primary aluminum-producing countries in 2021 (USGS 2022b).

In terms of value, the top 10 exporting countries account for 56% percent of total world aluminum export. According to the UN Comtrade database, the US, Japan, Mexico, South Korea, and Vietnam were the top five net importers (import minus export), and China, Russia, the UAE, Canada, and Norway were the top five net exporters (export minus import) of aluminum in 2019 (Table 3). The significant global trade of such a carbon-intensive commodity has substantial implications for the embodied carbon in traded aluminum, as discussed in our recent study (Hasanbeigi and Darwili, 2022). This embodied carbon in traded aluminum often is not accounted for in national and international carbon accounting and climate policies.

Table 3. Top 10 net importers and exporters of aluminum in 2019 (UN Comtrade 2022)

Country	Net Imports (million $)	Country	Net Exports (million $)
USA	11,352	China	20,314
Japan	5,815	Russia	4,643
Mexico	5,296	United Arab Emirates	4,427
South Korea	2,773	Canada	4,309
Vietnam	2,346	Norway	2,594
United Kingdom	2,235	Iceland	1,664
France	1,711	Australia	1,282
Thailand	1,505	Qatar	1,208
Indonesia	1,364	South Africa	1,130
Brazil	1,292	Mozambique	968

2.4. U.S. aluminum production and trade

In 2021, three companies operated six primary aluminum smelters in five States. Two smelters operated at full capacity, and four smelters operated at reduced capacity throughout the year. Another smelter remained on standby throughout the year, and one that had been on standby since 2015 was permanently shut down in December. The U.S. produced 0.88 Mt of primary aluminum and 3.2 Mt of secondary aluminum in 2021.

Primary aluminum refers to aluminum produced directly from mined ore. The ore is refined and electrolytically reduced to elemental aluminum in aluminum smelters. Secondary aluminum refers to aluminum that is produced from pre-consumer and post-consumer aluminum scraps.

The value of primary aluminum production was about $2.70 billion, 35% more than the value in 2020. Transportation applications accounted for 35% of domestic consumption, followed by packaging, 23%, and buildings, 16%. In 2021, the aluminum industry in the U.S. employed around 30,000 people (USGS 2022b).

The U.S. imported around 4.8 Mt and exported around 0.82 Mt of Crude and semi-manufactured aluminum products in 2021 (USGS 2022b). Figure 8 shows the top countries that the U.S. imported aluminum products in 2019. Canada was the top exporter of aluminum to the U.S. (44% of total U.S. imports), followed by the United Arab Emirates (UAE) (9%), Australia (5%), and India (5%).

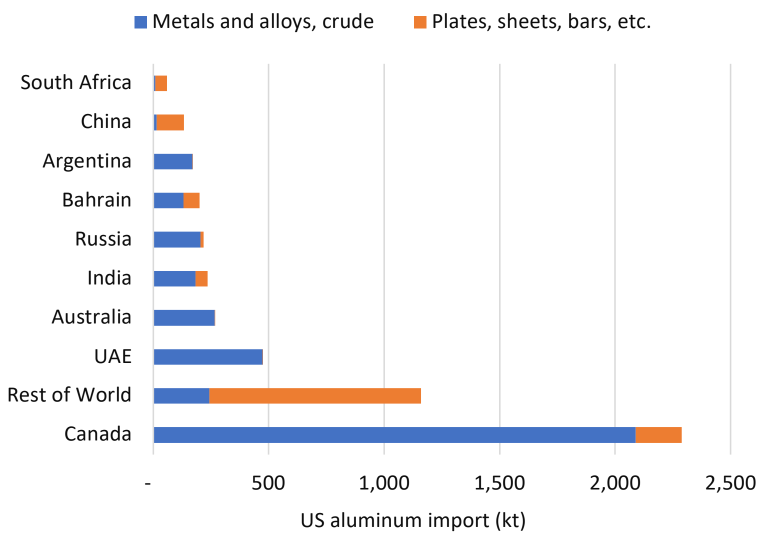


Figure 8. U.S. import of aluminum products in 2019 by country of origin (USGS 2022b) .

Figure 9 shows the top countries to which the U.S. exported aluminum in 2019. Mexico and Canada together account for 83% of the U.S. steel export.

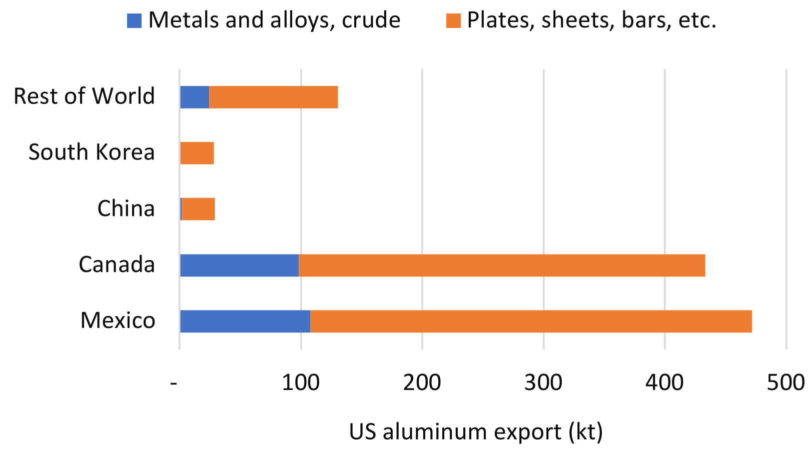


Figure 9. The U.S. export of aluminum products in 2019 by country of destination (USGS 2022b) .

3 CO_2 Emissions from Global Steel and Aluminum Industry

3.1. CO_2 emissions from the global steel industry

The Global steel industry emitted around 3.6 gigatons of CO_2 (Gt CO_2) emissions in 2019. Global BF-BOF steel production emitted around 3.1 Gt CO_2, and global EAF steel production emitted around 0.5 Gt CO_2 in 2019. The high CO_2 intensities of EAFs in China and India because of their use of a large share of pig iron or coal-based direct reduced iron (DRI) as feedstock instead of steel scrap in EAFs causes an increase in global EAF's CO_2 emissions (Hasanbeigi 2022).

In our previous study (Hasanbeigi 2022), we also estimated the total CO_2 emissions from the steel industry in each of the countries studied based on our estimated CO_2 intensities for BF-BOF and EAF by country and the amount of production in each country. Figure 10 shows the results of this analysis, with China standing out as responsible for 54% of the global steel industry's CO_2 emissions.

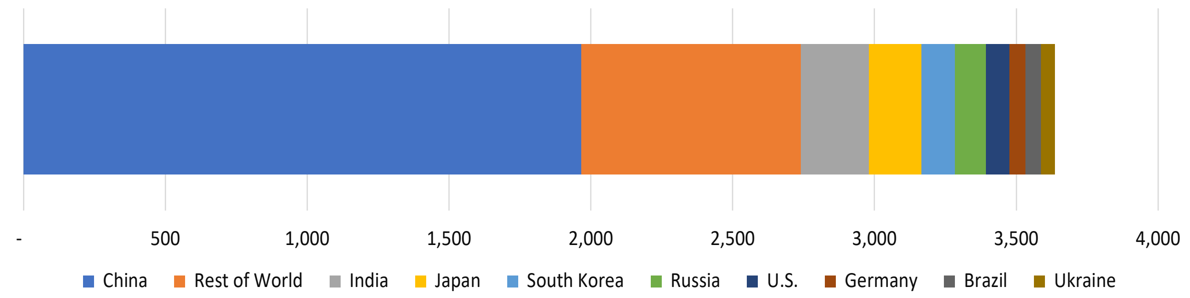


Figure 10. Total CO_2 emissions (Mt CO_2) from steel production in major producing countries 2019 (in Mt CO_2) (Hasanbeigi 2022) .

Based on the total steel industry emissions presented above and the global GHG emissions of 52 Gt $CO_{2\text{-}e}$ in 2019 (including non-CO2 GHG emissions as well) reported in UNEP (2020), the global steel industry accounts for around 7% of total global GHG emissions. Based on the total steel industry emissions presented above and the global CO_2 emissions of 33 Gt CO_2 in 2019 reported by IEA (2020), the global steel industry accounts for around 11% of total global CO_2 emissions.

It is worth highlighting that only the annual GHG emissions of two countries, i.e., China and the U.S. are higher than the annual CO_2 emissions of the global steel industry.

3.2. CO_2 emissions from the global aluminum industry

The total global energy-related CO_2 emissions from *primary* aluminum production in 2019 were 656 Mt CO_2 (Hasanbeigi et al. 2022). Fuel use is almost entirely consumed during the alumina production phase, which also consumes some electricity. Around 19% of emissions in primary aluminum production are from fuel use, while 81% of emissions come from electricity use. This indicates that decarbonization efforts for primary aluminum production should be focused on electricity but that alumina production should also be oriented toward lower carbon fuels, given the presence of carbon neutrality goals in many of the countries studied. The fuel vs. electricity mix also ranges from country to country because some countries, like Canada, Iceland, and Norway, use essentially zero-emissions electricity for aluminum production, while other countries, like India, use carbon-intensive fuels both for electricity used in the electrolysis phase and alumina production (Hasanbeigi et al. 2022).

Figure 11 shows the total energy-related CO_2 emissions from major *primary* aluminum-producing countries. China stands out as responsible for 67% of estimated global energy-related CO_2 emissions – more than its production share due to the high CO_2 intensity of primary aluminum production in China.

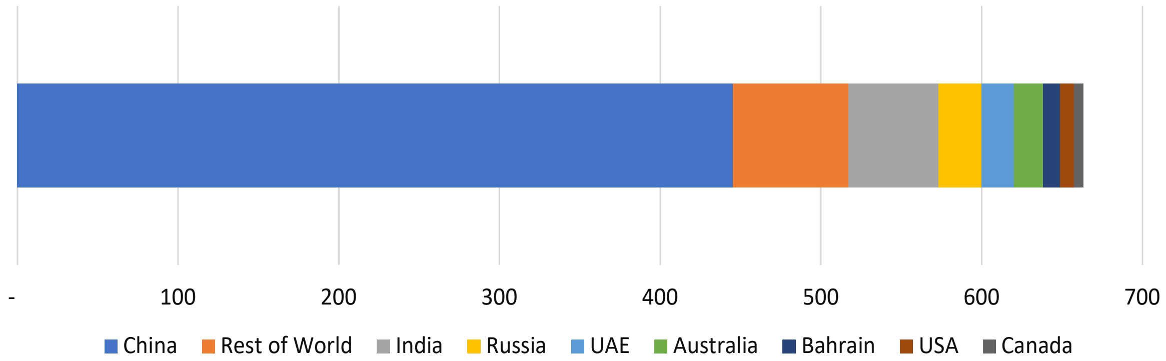


Figure 11. Total energy-related CO_2 emissions (Mt CO_2) from primary aluminum production in major producing countries in 2019 (Hasanbeigi et al. 2022) .

The CO_2 intensity of scrap-based secondary aluminum production is substantially lower (90%-95% lower) than that of primary aluminum production. The CO_2 intensity of secondary aluminum production ranges from 0.3 to 0.6 t CO_2/t aluminum (IAI 2021). Assuming a CO_2 intensity of secondary aluminum equal to 0.5 t CO_2/t aluminum and multiplying it by the secondary aluminum production in 2019 (15.5 Mt), we estimated total CO_2 emissions from secondary aluminum production equal to 8 Mt CO2 in 2019. This is around 1% of the total aluminum industry's (primary and secondary combined) CO_2 emissions in 2019.

While in theory, aluminum could be recycled over and over indefinitely, in practice, for some applications, we will continue using the primary aluminum since the smallest impurities could significantly change the properties.

Based on the total aluminum industry's energy-related emissions presented above and the global CO_2 emissions of 33 Gt CO_2 in 2019 reported by IEA (2020), the global aluminum industry accounts for around 2% of total global CO_2 emissions.

It is worth highlighting that if the global aluminum industry represented a country, it would be the 10th largest emitter of annual energy-related CO_2 emissions in the world.

4 Carbon Competitiveness of the U.S. Steel and Aluminum Industry

4.1. Carbon competitiveness of the U.S. steel industry

The U.S. steel industry has the 2nd lowest CO_2 emissions intensity among all major steel-producing countries. Hasanbeigi (2022) shows the ranking of the CO_2 emissions intensity of the steel industry in major steel-producing countries (Figure 12).

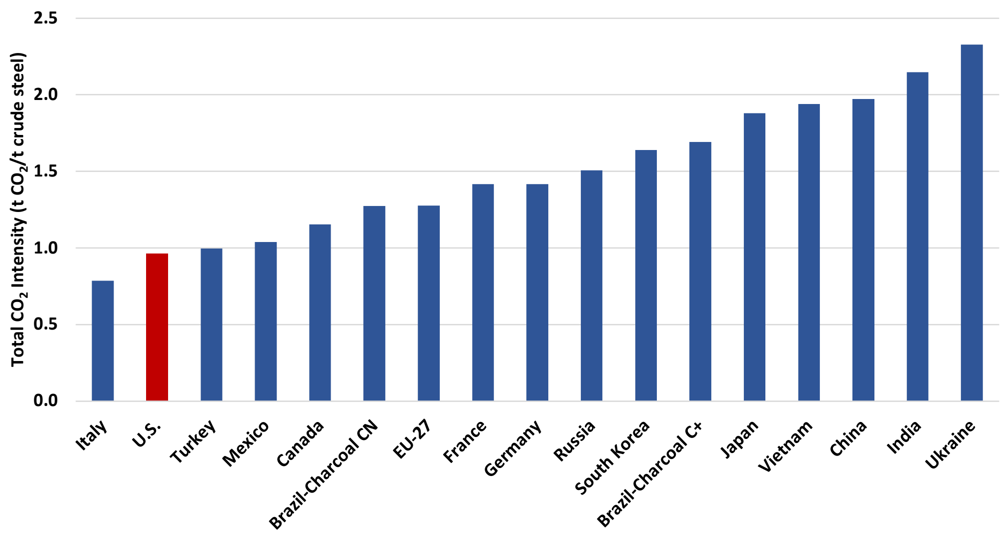


Figure 12. Total CO_2 emissions intensity of the steel industry in 2019 (Hasanbeigi 2022)
Note: Brazil-Charcoal CN refers to when charcoal is considered carbon neutral. Brazil-Charcoal C+ refers to when charcoal is not considered carbon neutral because of questions and concerns regarding the sustainability of biomass used in the steel industry in Brazil.

The U.S. has the 2nd lowest CO_2 emissions intensity among all major steel producing countries.

Italy, U.S., and Turkey have the lowest CO_2 emissions intensity. This is primarily because of a significantly high share of EAF steel production in total steel production in these countries (Figure 13). EAF is a secondary steel production process that primarily uses steel scrap and therefore uses less energy to produce a tonne of steel compared to BF-BOF. In other words, a higher share of EAF production helps reduce the overall energy and CO_2 emissions intensity of the steel industry in a country. It should be noted that EAF can also use direct reduced iron (DRI) or even pig iron (which is produced by BF) which are energy-intensive feedstock to EAF. In some countries like India, a high amount of DRI is used in EAF, and in China a large amount of pig iron is used in EAF, both resulting in significantly higher energy and emissions intensity for the steel produced by EAF in those countries. Other factors also impact the energy and CO_2 emissions intensity of the steel industry, as discussed in Hasanbeigi (2022).

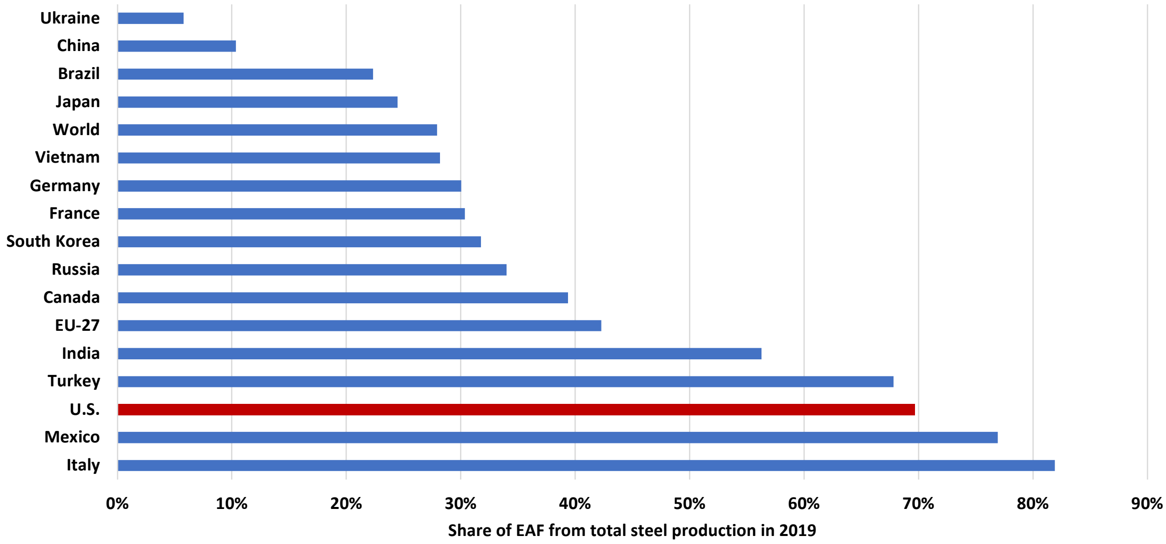


Figure 13. The share of EAF from total steel production in 2019 (Hasanbeigi 2022) .

In addition to the high share of EAF, two additional reasons why the U.S. ranks well for its CO_2 emissions intensity are 1) the high share of natural gas used in the U.S. steel industry (54% of total fuel used in the steel industry in the U.S.). Natural gas has a significantly lower emissions factor per unit of energy compared to coal and coke, which are the primary type of energy used in the steel industry in many countries. 2) The U.S. also has a relatively lower CO_2 grid emissions factor than many other steel-producing countries.

On the other hand, Ukraine, India, and China have the highest CO_2 emissions intensity among the countries studied. Ukraine, China, and Brazil also have the lowest share of EAF steel production. While India's steel industry has a high share of EAF steel production (56 %), its CO_2 emissions intensity is relatively high. This is mainly because, unlike in many other countries, a substantial amount of DRI is used as the feedstock for EAFs in India (around 50% of total EAF feedstock). Unlike recycled steel scrap, DRI is produced from iron ore using the direct reduction process, which is an energy- and carbon-intensive process. In addition, India is one of the few countries in the world that uses coal-based DRI technology instead of the natural gas-based DRI used in most countries around the world. This contributes to higher energy intensity and emissions for DRI-EAF steel produced in India.

Because BF-BOF and EAF steel production routes are quite different and thus their CO_2 emissions intensity are also significantly different from each other, it is also important to look at the steel production in each country for each production route, i.e., primary steelmaking by BF-BOF Vs. the secondary steelmaking by EAF.

Figure 14 shows the CO_2 intensity of BF-BOF steel production in major steel-producing countries in 2019 (Hasanbeigi, 2022). It is worth highlighting that even though China has the 3rd highest CO_2 intensity for its entire steel industry, its ranking improved for the CO_2 intensity for the BF-BOF steel production route. Although the very low share of EAF steel production in China results in a high total CO_2 intensity for its entire steel industry, more than 80% of the BF-BOF steel production capacity in China was built after the year 2000, with an average age of plants around 15 years. Many of these new plants are using more efficient production technology. In addition, in the past ten years, China has been aggressively shutting down old and inefficient steel plants.

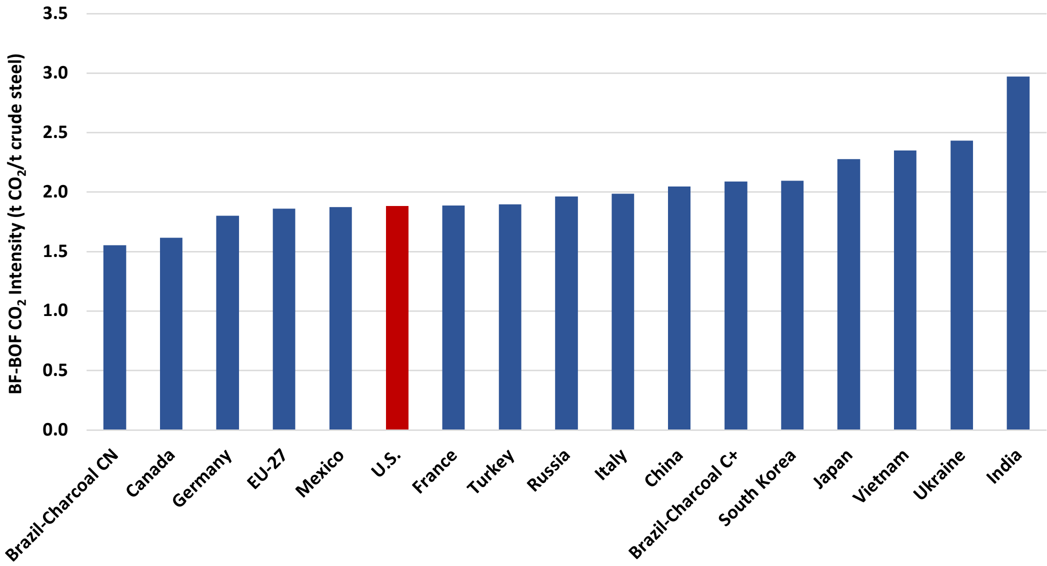


Figure 14. The CO_2 intensity of BF-BOF steel production in 2019 (Hasanbeigi 2022) .

Note: Brazil-Charcoal CN refers to when charcoal is considered carbon neutral. Brazil-Charcoal C+ refers to when charcoal is not considered carbon neutral because of questions and concerns regarding the sustainability of biomass used in the steel industry in Brazil.

India has the highest CO_2 intensity of BF-BOF steel production mainly because of many old and inefficient BF-BOF plants still operating in India. It should be noted, however, that some of the newly built steel plants in India are among the world's most efficient.

Figure 15 shows the CO_2 intensity of EAF steel production in the major steel-producing countries (Hasanbeigi, 2022). Brazil and France have the lowest, and India and China have the highest CO_2 intensity of EAF steel production. A key reason why the CO_2 intensity of EAF steel production in India, China, and Mexico are significantly higher than that in other countries is the type of feedstock used in EAF in these countries. In most countries, steel scrap is the primary feedstock for EAF. In India and Mexico, however, a substantial amount of DRI (around 50% in India and 40% in Mexico) is used as feedstock in EAFs (Worldsteel 2021). In China, instead of DRI, a significant amount of pig iron (around 50% of EAF feedstock), which is produced via BF, is used as feedstock in EAFs. Both DRI and pig iron production are highly energy-intensive processes, which result in higher energy and CO_2 intensity of EAF steel production when used as feedstock in EAFs. Another important factor that influences the CO_2 intensity of EAF steel production is the electricity grid CO_2 emissions factor. France, Brazil, and Canada have the lowest electricity grid CO_2 emissions factors thanks to large nuclear (in France) and hydro (in Brazil and Canada) power generation. Vietnam's high CO_2 intensity of EAF steelmaking can be mainly attributed to its very high electricity grid CO_2 emissions factor.

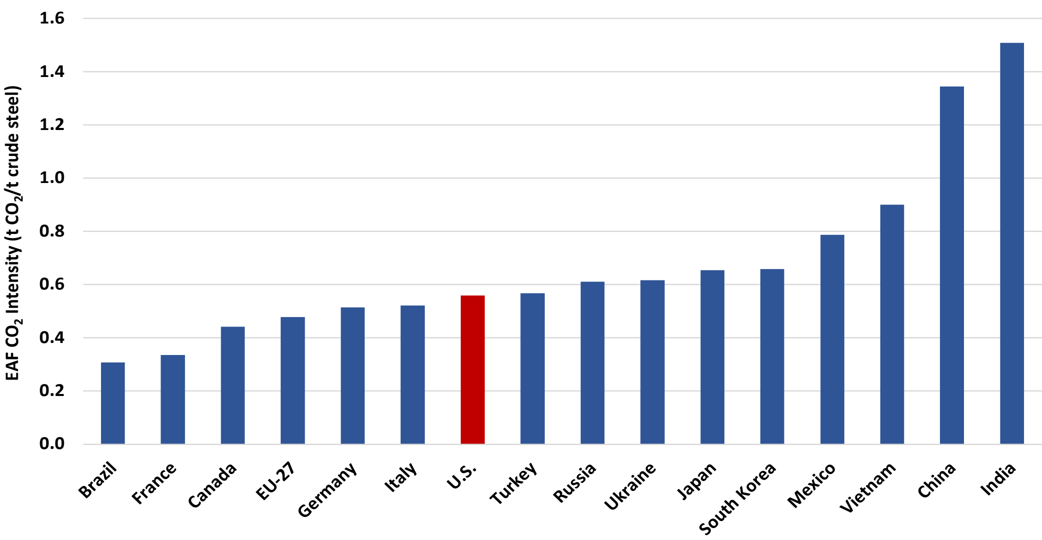


Figure 15. The CO_2 intensity of EAF steel production in 2019 (Hasanbeigi 2022) .

4.2. Carbon competitiveness of the U.S. aluminum industry

Figure 16 shows the final CO_2 intensity of aluminum production, including the energy-related CO_2 emissions intensity of alumina production as well as for electrolysis in aluminum smelters (Hasanbeigi et al. 2022). The CO_2 emissions associated with both electricity and fuel use are included. In some countries, captive power plants are used to generate electricity for aluminum production, while in other countries, the electricity for electrolysis primarily comes from the grid. There is a huge variation in the CO_2 intensity of primary aluminum production in the countries. Iceland, Norway, and Canada, which have very low-carbon electricity used in aluminum plants, have the lowest CO_2 intensity, while India, China, and Australia have the highest CO_2 intensity for primary aluminum production. The U.S. primary aluminum production's CO_2 intensity falls somewhere in the middle of the range shown in Figure 16.

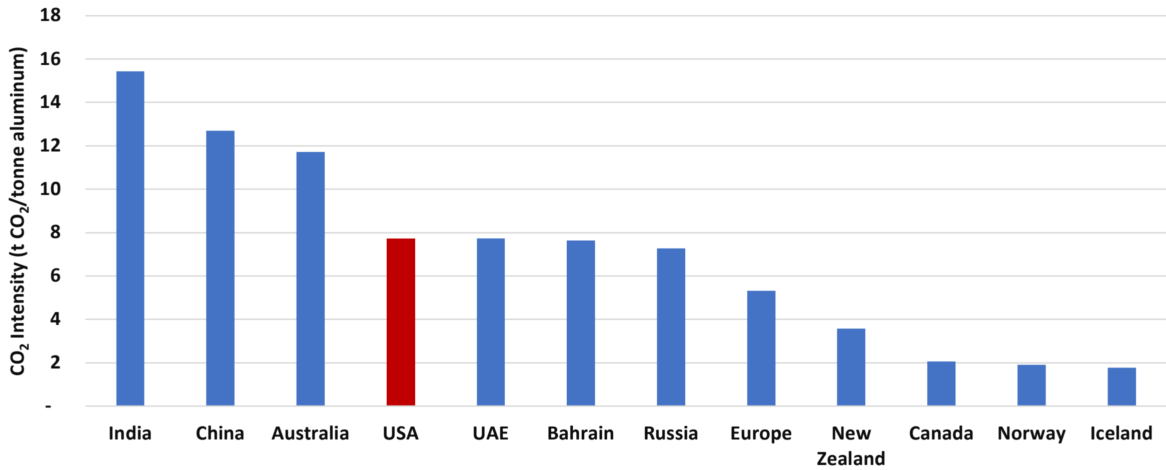


Figure 16. Final energy-related CO_2 intensity of *primary* aluminum production in 2019 (Hasanbeigi et al. 2022) .

Note: Both smelters and alumina production processes are included. The CO_2 emissions from both electricity and fuel use are included.

Figure 16 and the ranking explained above are for primary aluminum production from mined ore through smelters. The CO_2 intensity of scrap-based secondary aluminum production is substantially lower than that of primary aluminum production. The CO_2 intensity of secondary aluminum production ranges from 0.3 to 0.6 t CO_2/t aluminum (IAI 2021). Rotary drums or hearth furnaces are used to melt down the aluminum scrap and the materials containing aluminum. Often natural gas is used as a fuel in these furnaces where natural gas is available. There is no sufficient country-specific data on the CO_2 intensity of *secondary* aluminum production in different countries.

5 Impact of U.S. Border Carbon Adjustment on GHG Emissions and Revenue

5.1 Methodology and scenario definitions

We conducted a quantitative analysis to assess the impact of a U.S. BCA on the GHG emissions from the steel and aluminum industry, revenue generated by BCA, trade quantity and value, and the U.S. steel and aluminum industry's revenue. We conducted this analysis for U.S. BCA on three products:

1) Steel products
2) Aluminum products
3) Steel contained in passenger cars

To do this analysis, we assumed the following:

- U.S. BCA will come into effect in 2024.
- Conducted the analysis for 2024 to 2030.
- Assumed three different levels of the carbon price (LOW, MED, HIGH) as defined in Table 4. The MED price level is similar to the one proposed in the recent Clean Competition Act (Office of Senator Sheldon Whitehouse, 2022).
- Assumed a 5% increase in carbon price per year.

Table 4 Carbon price levels used in this study (US$/t CO_2)

Carbon price levels	2024	2030
LOW	30	40
MED	55	74
HIGH	70	94

- In all scenarios, the U.S. domestic steel and aluminum producers are also subject to a carbon levy, shown in Table 4, if their CO_2 intensity is above the intensity baseline. They would pay the carbon levy only on the fraction of emissions that exceed the industry average carbon intensity baseline.
- Except in scenario 3, in all other scenarios, the U.S. domestic intensity baseline for the steel industry is the weighted average intensity of BF/BOF and EAF steelmaking. Therefore, all BF/BOF steel production facilities are above the domestic intensity baseline and must pay the carbon levy only on the fraction of emissions that exceed the steel industry's CO_2 intensity baseline.
- Except in scenario 3, in all other scenarios, the U.S. domestic intensity baseline for the aluminum industry is the weighted average intensity of primary aluminum making (using smelters) and secondary aluminum production (from the scrap). Therefore, all primary aluminum production facilities are above the domestic intensity baseline and must pay the carbon levy only on the fraction of emissions that exceed the aluminum industry's CO_2 intensity baseline.
- Any carbon levy paid by domestic producers is refunded for the portion of productions that are exported.
- The 2021 annual steel and aluminum production data were used in this analysis. We assumed the same annual production of steel and aluminum in the U.S. between 2024 and 2030.

- Both scope 1 (onsite emissions) and Scope 2 (mainly electricity-related emissions) are included in this analysis.
- Assumed a conservative 1% per year reduction in average CO_2 intensity of steel and aluminum production between 2024 and 2030 in both U.S. and other countries. This can vary widely from country to country. For example, in countries with a larger share of primary steelmaking or primary aluminum making, a shift to scrap-based secondary steel or aluminum making will help to decrease the CO_2 intensity more substantially. However, it was outside the scope of this work to do such country-specific intensity forecasts.
- The CO_2 intensity reduction rate will not play an important role in our analysis when the same rate is applied both to the U.S. and the countries the U.S. is importing from. This is because, in our scenarios, the *difference* (i.e., delta) between the CO_2 intensity for steel and aluminum produced in the U.S. and countries the U.S. is importing these products from being used in the analysis. Since the scale of such improvement in all these countries is unknown up to 2030, and it was out of the scope of this study to investigate it, we decided to assume the same rate of CO_2 intensity reduction across all countries. Therefore, the delta in CO_2 intensity for steel and aluminum between the U.S. and the countries it is importing from in 2024 and 2030 will remain the same.

It should be noted that we used country-level carbon intensities in this analysis. This is a simplification because of the lack of more granular data. In reality, a BCA policy will ask for plant- or product-specific carbon intensity.

We then developed three distinct scenarios for this analysis that vary in terms of which CO_2 intensity is to be used for the products and how they are applied to imported/exported products. These three scenarios are explained in more detail below.

Scenario 1: Average CO_2 intensity of steel and aluminum in each country is used (Has domestic CO_2 price):

In this scenario, for the U.S. and all countries that the U.S. is importing steel or aluminum from, we used the average CO_2 intensity of steel and aluminum in each country in our analysis. We mainly used our two recent benchmarking reports for CO_2 intensity values of the steel and aluminum industry in different countries (Hasanbeigi 2022, Hasanbeigi et al. 2022). For a few countries where we didn't have the intensities from these reports or other sources, we used regional averages. The carbon levy on imports is applied to the difference between the CO_2 intensity of U.S. steel and aluminum production and the CO_2 intensity in countries the U.S. imports steel and aluminum. This scenario also includes a carbon levy for domestic steel and aluminum producers whose CO_2 intensity is above the U.S. industry baseline (see above for our explanation of baseline calculation). Scenario 1 is the most straightforward and logical approach that we recommend being initially used for a U.S. BCA for steel and aluminum.

Scenario 2: Average CO_2 intensity of steel and aluminum used for developed countries and economy-wide intensity for developing countries (Has domestic CO_2 price) :

In this scenario, for the U.S. and all developed countries that the U.S. is importing steel or aluminum from, we used the average CO_2 intensity of steel and aluminum in each country in our analysis. But for the developing countries where the quality of energy use or CO_2 intensity data reported has raised questions, we used an economy-wide CO_2 intensity approach. Such an approach is also suggested by the recent Clean Competition Act introduced in June 2022 by Senator Sheldon Whitehouse (Office of Senator Sheldon Whitehouse, 2022).

In this approach, we first find the economy-wide CO_2 intensity for different developing countries the U.S. is importing steel and aluminum from. The source of economy-wide intensities for each country is WIOD (WIOD 2022) (see Appendix 1). We then calculate the ratio of the economy-wide CO_2 intensity of each developing country to the economy-wide CO_2 intensity of the US. We multiply that ratio by the CO_2 intensity of the steel or aluminum produced in the U.S., and the result will be a proxy for the CO_2 intensity of the steel or aluminum produced in that developing country.

While this approach may give a reasonable result for the steel industry, it will give a substantially unreasonable result for the aluminum industry by rewarding the highest carbon-intensive aluminum producers. This is because the weighted average CO_2 intensity of the U.S. primary and secondary aluminum production is around 2.1 t CO_2 /t aluminum. This is substantially lower than some of the major countries the U.S. is importing from, such as India (13.4 t CO_2 /t aluminum), China (10.9 t CO_2 /t aluminum), and UAE (7.5 t CO_2 /t aluminum). If we multiply the ratio of the economy-wide CO_2 intensity of India, China, and UAE to the U.S.

economy-wide CO_2 intensity (3.7, 3.2, 1.8, respectively) with the average U.S. aluminum production intensity of 2.1 t CO_2 /t aluminum, the results (7.7 for India, 6.5 for China and 3.8 for UAE) are substantially lower than actual aluminum production CO_2 intensity in these countries. This analysis shows that using economy-wide CO_2 intensity for developing countries as an approach for U.S. BCA implementation for aluminum as suggested in the Clean Competition Act (Office of Senator Sheldon Whitehouse 2022) is not methodologically sound and does not reward aluminum producers in the U.S. and other countries with truly lower carbon intensity. Therefore, we do not suggest this method. We included this scenario in our study to illustrate its impact and implications if such an approach is used.

The carbon levy on imports is applied to the difference between the CO_2 intensity of U.S. steel and aluminum production and the CO_2 intensity estimated in this manner for developing countries. This scenario also includes a carbon levy for domestic steel and aluminum producers whose CO_2 intensity is above the U.S. industry baseline.

Scenario 3: Country-specific primary and secondary steel and aluminum CO_2 intensity are considered separately (Has domestic CO_2 price):

This scenario is the same as scenario 1 explained above. The only difference is that in this scenario, instead of using the weighted average intensity of primary and secondary steelmaking or aluminum making as the baseline for the analysis, we used the country-specific primary and secondary steel and aluminum CO_2 intensity separately. For this, we broke down the imported steel and aluminum from each country to the U.S. into primary and secondary steel and aluminum based on the ratio of primary and secondary steel and aluminum production in each country that the U.S. is importing from. We took this simplified approach since we did not have sufficient data on the type of process that each steel and aluminum product imported is produced from. We then compared the CO_2 intensity of the imported primary and secondary steel and aluminum to that in the U.S. when doing the analysis. The carbon levy on imports is applied to the difference between the CO_2 intensity of primary and secondary steel and aluminum production in the U.S. and other countries it imports from. As our results show, this has a major implication on both GHG emissions reduction and the revenue impact of BCA.

This scenario also includes a carbon levy for domestic steel and aluminum producers whose CO_2 intensity is above the U.S. industry baseline set separately for primary and secondary steel and aluminum producers.

5.2. Impact of U.S. border carbon adjustment on steel

Using the method and assumptions described in the previous section, we quantified the impact of a hypothetical U.S. BCA for steel. Figure 17 shows the annual import revenue of BCA for steel under different scenarios in Million $/year. This is only import revenue and does not include the revenue from a domestic carbon levy. Scenario 2 has the highest annual import revenue. However, the difference between scenario 1 and scenario 2 is not as substantial, while scenario 1 has a more straightforward and reasonable approach by using the average CO_2 intensity of steel in each country rather than using an economy-wide intensity for developing countries (scenario 2). Under MED carbon price, the annual import revenue of BCA for steel ranges from $161 million in scenario 3 to $867 million in scenario 2 in 2024 and from $216 million in scenario 3 to $1,162 million in scenario 2 in 2030.

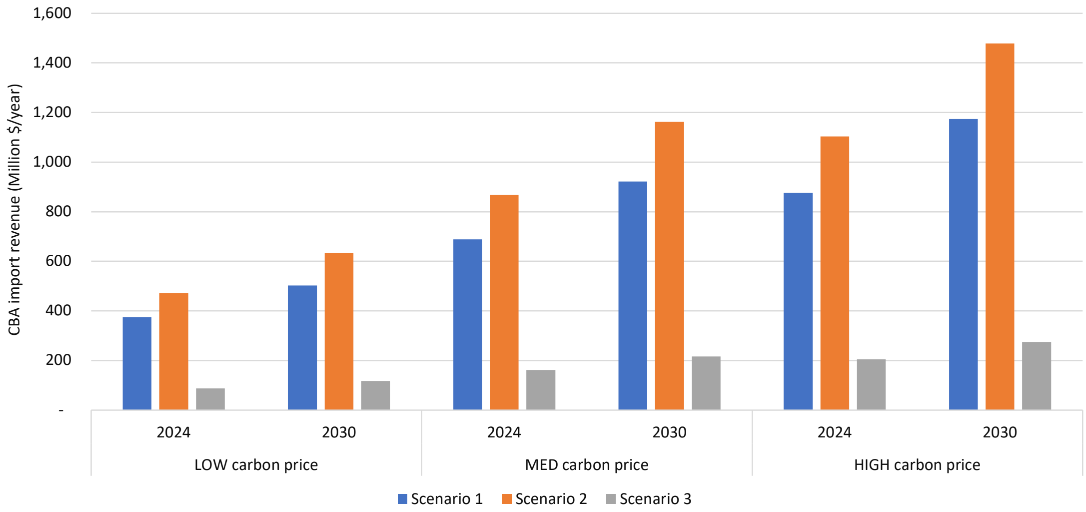


Figure 17. Annual import revenue of BCA for steel (Million $/year) (Source: this study) .

Scenario 1: Average CO_2 intensity of steel in each country is used (Has domestic CO_2 price)

Scenario 2: Average CO_2 intensity of steel used for developed countries and economy-wide intensity for developing countries (Has domestic CO_2 price)

Scenario 3: Country-specific primary and secondary steel CO_2 intensity are considered separately (Has domestic CO_2 price)

Scenario 3, which uses country-specific primary and secondary steel CO_2 intensity separately, has the lowest annual import revenue potential compared to other scenarios. This is primarily because the U.S. steel industry's carbon advantage is substantially reduced if the carbon intensity of its primary and secondary steelmaking is compared with that of primary and secondary steelmaking in other countries. When comparing the carbon intensity of the Bf-BOF or EAF in the U.S. and those in the other countries separately, the difference in intensities is not that large. However, since 71% of the steel in the U.S. is produced by EAF, which has substantially lower carbon intensity compared to BF/BOF, the weighted average carbon intensity of the steel industry is substantially lower than the average carbon intensity of other countries. That is why other scenarios (1, 2, and 4) show much higher annual import revenue potential.

It should be noted that these revenue estimates might be on the higher side because existing trade flows, on which the revenue estimates are based, could be substantially modified by the border carbon charges. Cleaner producers of steel could export to the US, and dirtier steel producers might reduce their exports to the U.S.

We also converted the annual import revenue of BCA for steel into US$ per tonne of steel (Figure 18). The relative ranking of revenue across scenarios and carbon price levels remained the same as in Figure 17 and explained above. Under MED carbon price, the annual import revenue of BCA for steel ranges from 6 $/t steel in scenario 3 to 34 $/t steel in scenario 2 in 2024 and from 9 $/t steel in scenario 3 to 46 $/t steel in scenario 2 in 2030 under different scenarios. The steel industry is a low-profit margin industry. These BCA import charges per tonne of steel shown in Figure 18, especially under scenarios 1 and scenario 2 will account for a substantial share of steel companies' profit margin and will have major trade implications. This is discussed further below.

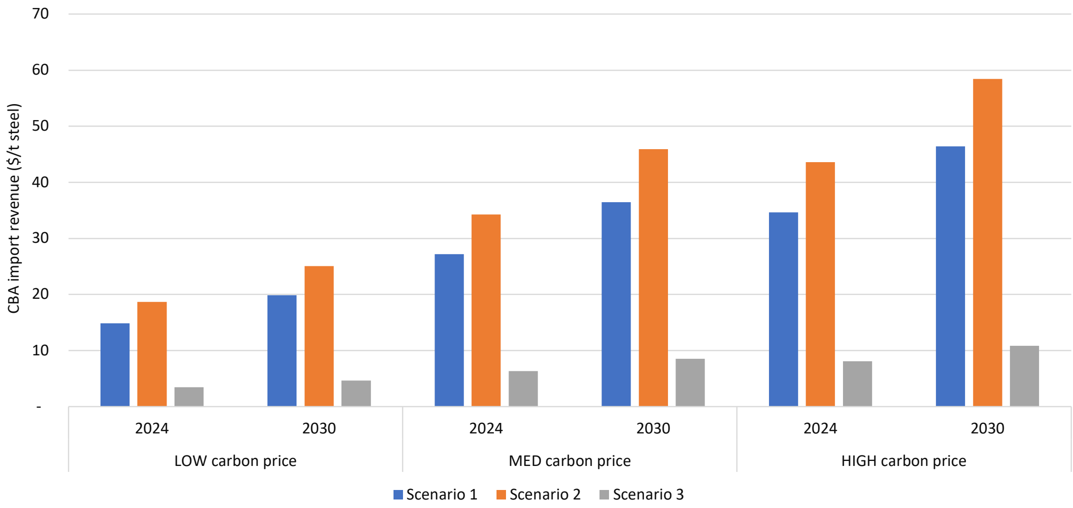


Figure 18. Annual import revenue of BCA for steel ($/t steel) (Source: this study) .

Scenario 1: Average CO_2 intensity of steel in each country is used (Has domestic CO_2 price)

Scenario 2: Average CO_2 intensity of steel used for developed countries and economy-wide intensity for developing countries (Has domestic CO_2 price)

Scenario 3: Country-specific primary and secondary steel CO_2 intensity are considered separately (Has domestic CO_2 price)

The two figures above only show the annual import revenue of BCA. But the U.S. BCA scenarios also have export rebates, and in scenarios 1, 2, and 3 it also has a domestic carbon levy paid by the domestic producers. Adding the domestic revenue from the carbon levy paid by domestic steel producers whose carbon intensity is above the baseline (see section 5.1.) and deducting the export rebate paid to U.S. steel exporters will result in the total annual revenue of BCA for steel (Figure 19). Scenario 2 has the highest *total* annual revenue of BCA for steel. Under MED carbon price, the total annual revenue of BCA for steel ranges from $578 million in scenario 3 to $2,047 million in scenario 2 in 2024 and from $775 million in scenario 3 to $2,743 million in scenario 2 in 2030.

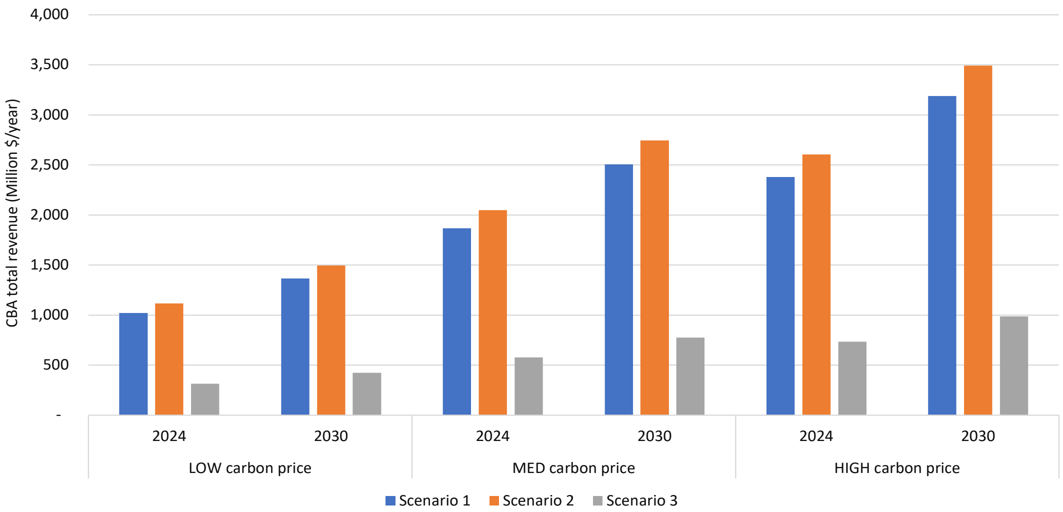


Figure 19. Total annual revenue of BCA for steel (import plus net domestic revenue after export rebate) (Million $/year) (Source: this study) .

The revenue generated by U.S. BCA for steel varies across different scenarios, as shown above. The ratio of steel BCA import revenue to BCA's total revenue also varies across scenarios (Table 5). Scenario 3 has the lowest ratio meaning less revenue is generated from the steel import carbon levy, and more revenue is generated from the domestic carbon levy under scenario 3.

Table 5. The ratio of steel BCA import revenue to CAB total revenue (Source: this study)

Scenario	The ratio of BCA import revenue to CAB total revenue
Scenario 1	37%
Scenario 2	42%
Scenario 3	28%

Table 5 shows that even if only 75% of the total revenue from a U.S. BCA for steel is spent domestically, with the remaining 25% spent internationally to help decarbonize the industry sector in developing countries, it still will put substantially more money back into the U.S. industry than the carbon levy domestic producers will have to pay (The ratio of steel BCA import revenue to BCA total revenue is larger than 25%).

The reduction in imported steel as a result of U.S. BCA for steel under MED carbon price in Scenario 1 is equal to 26% in 2024 and 55% in 2030 of total imported steel in the U.S. compared to 2019 level (Figure 20). The reduction in U.S. steel imports does not impact the steel that the U.S. imports from Canada or Mexico because these two countries meet the carbon intensity threshold. Since Canada and Mexico account for around 90% of the U.S. steel export market (USGS 2022a), the direct impact of retaliatory measures by countries that see a reduction in steel export to the U.S. is minimal on the U.S. steel industry. Also, in 2021, the total steel production capacity in the U.S. was 106 Mt, while the actual steel production was 87 Mt in that year (USGS 2022a). Therefore, there is room for the U.S. steel producers to increase production to accommodate most of the new demand caused by a reduction in U.S. imported steel as a result of the U.S. BCA for steel.

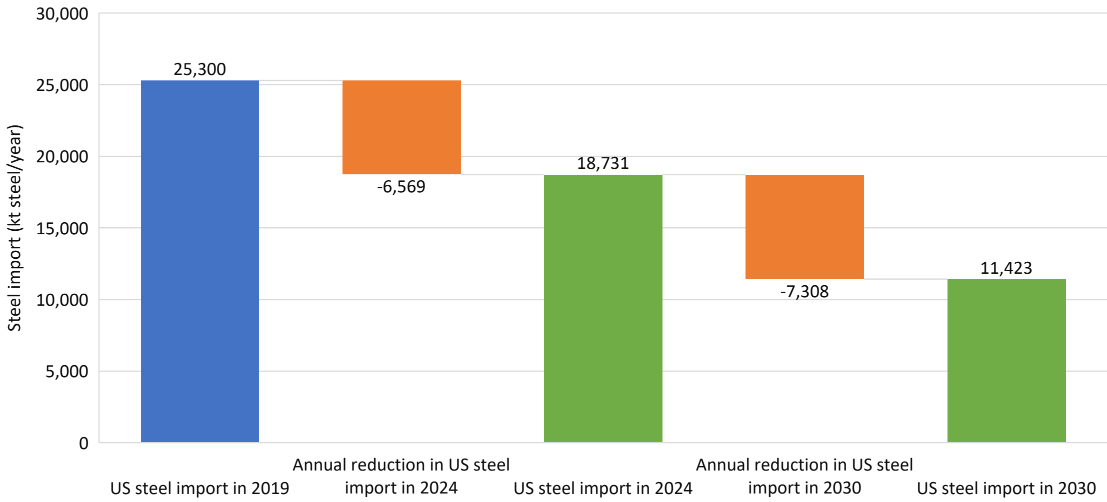


Figure 20. Reduction in annual imported steel as a result of U.S. BCA for steel under MED carbon price in Scenario 1 (Source: this study) .

The reduction in embodied carbon in imported steel as a result of U.S. BCA for steel under MED carbon price in Scenario 1 is equal to 15% in 2024 and 27% in 2030 of total embodied CO_2 in imported steel in the U.S. compared to the 2019 level (figure 21). This is because the weighted average CO_2 intensity of steel production in the U.S. (primary and secondary) is substantially lower than that in most other countries from which it is importing steel.

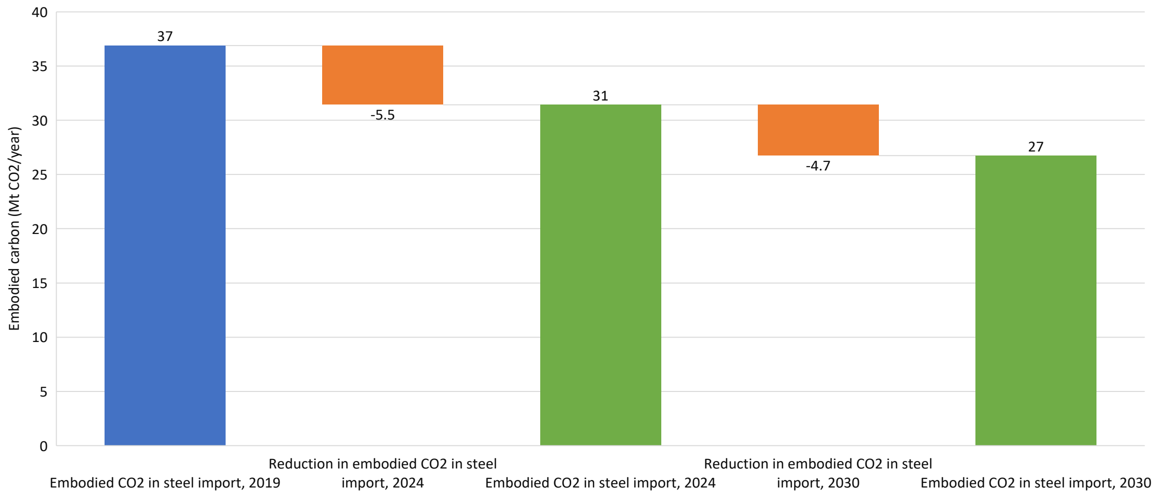


Figure 21. Reduction in annual embodied carbon in imported steel as a result of U.S. BCA for steel under MED carbon price in Scenario 1 (Source: this study) .

The increase in annual *revenue* of U.S. steel companies as a result of reduced U.S. imports from U.S. BCA under MED carbon price in Scenario 1 is around $4,000 million in 2024 and $8,500 million in 2030 (Figure 22). This translates into an increase in the total annual *net profit margin* of the U.S. steel companies resulting from the reduced import (Million $), which is estimated to be $ 600 million in 2024 and $ 1,270 million in 2030, assuming a 15% net profit margin for steel producers in the US.

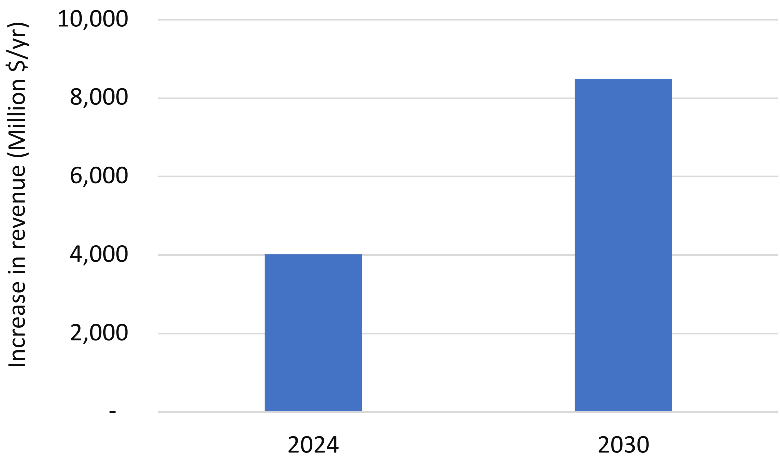


Figure 22. Increase in annual revenue of U.S. steel companies as a result of reduced U.S. import from U.S. BCA under MED carbon price in Scenario 1 (Source: this study) .

The increase in the U.S. steel industry's annual revenue resulting from the reduced steel import caused by U.S. BCA will be distributed across all regions in the U.S. (Figure 23). Assuming an even distribution of the increase in annual revenue across all steel companies, the top 5 steel producing states (Indiana, Ohio, Pennsylvania, Texas, and Illinois) account for more than half of the increase in annual revenue combined. The increase in the U.S. steel industry's annual revenue will more than double in 2030.

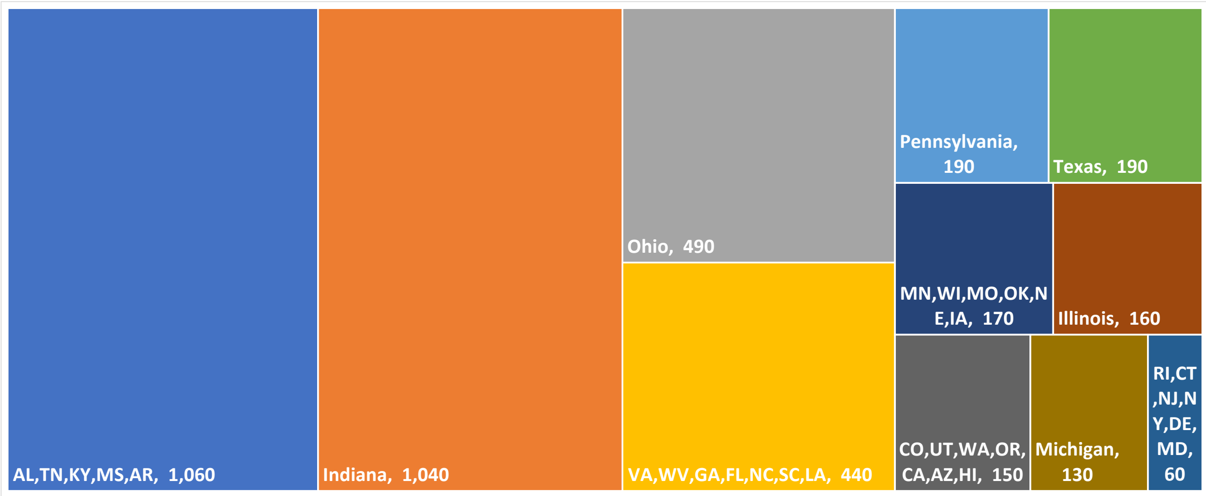


Figure 23. Estimated distribution of the increase in the U.S. steel industry's annual revenue by U.S. regions in 2024 as a result of reduced steel import caused by BCA (Million $) (Source: this study) .

5.3. Impact of U.S. border carbon adjustment on aluminum

In addition to steel, we also quantified the impact of a hypothetical U.S. BCA on aluminum. Figure 24 shows the annual import revenue of BCA for aluminum under different scenarios in Million $/year. Contrary to steel BCA, Scenario 1, which has a more straightforward and reasonable approach by using the average CO_2 intensity of aluminum in each country, has the largest annual import revenue for BCA. Under MED carbon price, the annual import revenue of BCA for aluminum ranges from $172 million in scenario 3 to $838 million in scenario 1 in 2024 and from $231 million in scenario 3 to $1,123 million in scenario 1 in 2030.

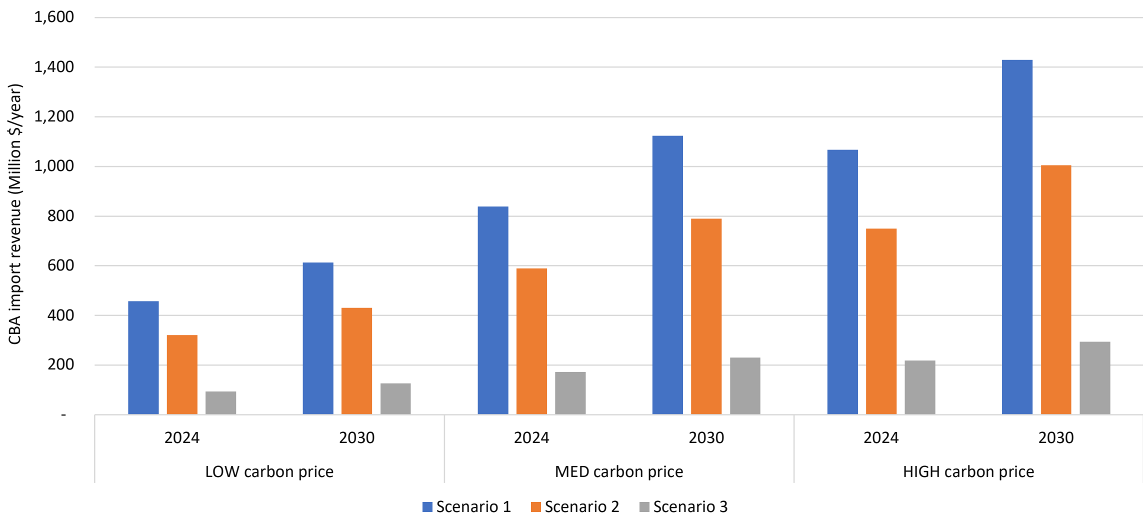


Figure 24. Annual import revenue of BCA for aluminum (Million $/year) (Source: this study) .

Scenario 1: Average CO_2 intensity of aluminum in each country is used (Has domestic CO_2 price)

Scenario 2: Average CO_2 intensity of aluminum used for developed countries and economy-wide intensity for developing countries (Has domestic CO_2 price)

Scenario 3: Country-specific primary and secondary aluminum CO_2 intensity are considered separately (Has domestic CO_2 price)

Scenario 3, which uses country-specific primary and secondary aluminum CO_2 intensity separately, has the lowest annual import revenue potential compared to other scenarios. This is primarily because the U.S. aluminum industry's carbon advantage over countries like Australia, China, India, and UAE, from which it imports large amounts of aluminum, is substantially reduced if the carbon intensity of its primary and secondary aluminum production is compared with that of primary and secondary aluminum production in other countries. However, since 78% of the aluminum in the U.S. is produced by secondary aluminum production from scrap, which has substantially lower carbon intensity compared to primary aluminum production, the weighted average carbon intensity of the aluminum industry is substantially lower than the average carbon intensity of most other countries except Canada, Norway, and Iceland. That is why other scenarios (1, 2, and 4) show a much higher annual import revenue potential.

Figure 25 shows the annual import revenue of BCA for aluminum in US$ per tonne of aluminum. The relative ranking of revenue across scenarios and carbon price levels remains the same as in Figure 24, and the reasons are explained above. Under MED carbon price, the annual import revenue of BCA for aluminum ranges from 33 $/t aluminum in scenario 3 to 161 $/t aluminum in scenario 1 in 2024 and from 44 $/t aluminum in scenario 3 to 216 $/t aluminum in scenario 1 in 2030 under different scenarios. These BCA import charges per tonne of aluminum shown in Figure 25, especially under scenarios 1 and scenario 2 will account for a substantial share of aluminum companies' profit margin and will have major trade implications. This is discussed further below.

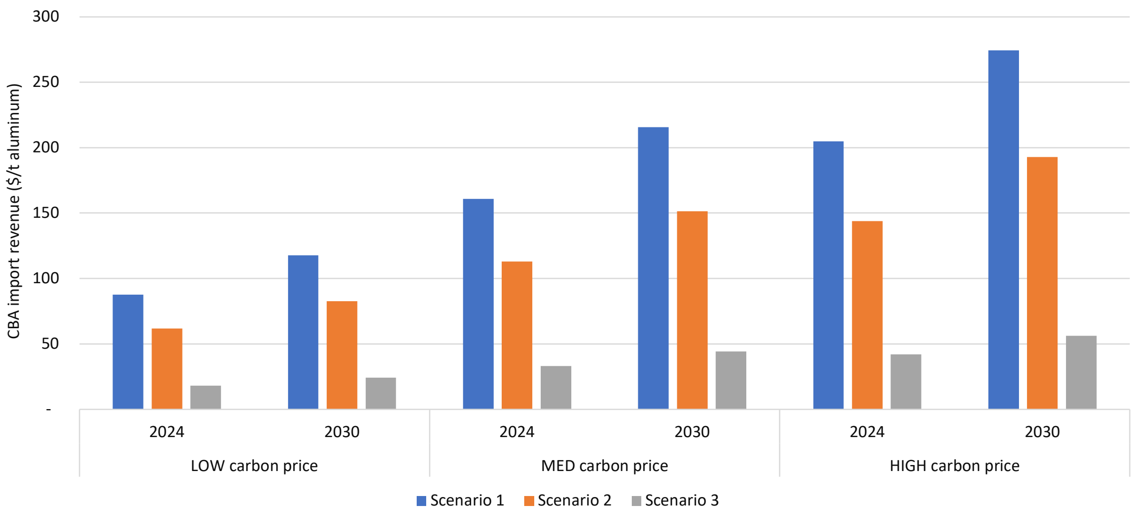


Figure 25. Annual import revenue of BCA for aluminum ($/t aluminum) (Source: this study) .

Scenario 1: Average CO_2 intensity of aluminum in each country is used (Has domestic CO_2 price)

Scenario 2: Average CO_2 intensity of aluminum used for developed countries and economy-wide intensity for developing countries (Has domestic CO_2 price)

Scenario 3: Country-specific primary and secondary aluminum CO_2 intensity are considered separately (Has domestic CO_2 price)

The U.S. BCA for aluminum also has an export rebate, and in scenarios 1, 2, and 3 it also has a domestic carbon levy paid by the domestic producers. Adding the domestic revenue from the carbon levy paid by domestic aluminum producers whose carbon intensity is above the baseline (see section 5.1.) and deducting the export rebate paid to U.S. aluminum exporters will result in the total annual revenue of BCA for aluminum (Figure 26). Scenario 1 still has the highest *total* annual revenue of BCA for aluminum. Under MED carbon price, the total annual revenue of BCA for aluminum ranges from $206 million in scenario 3 to $1,039 million in scenario 1 in 2024 and from $276 million in scenario 3 to $1,393 million in scenario 1 in 2030.

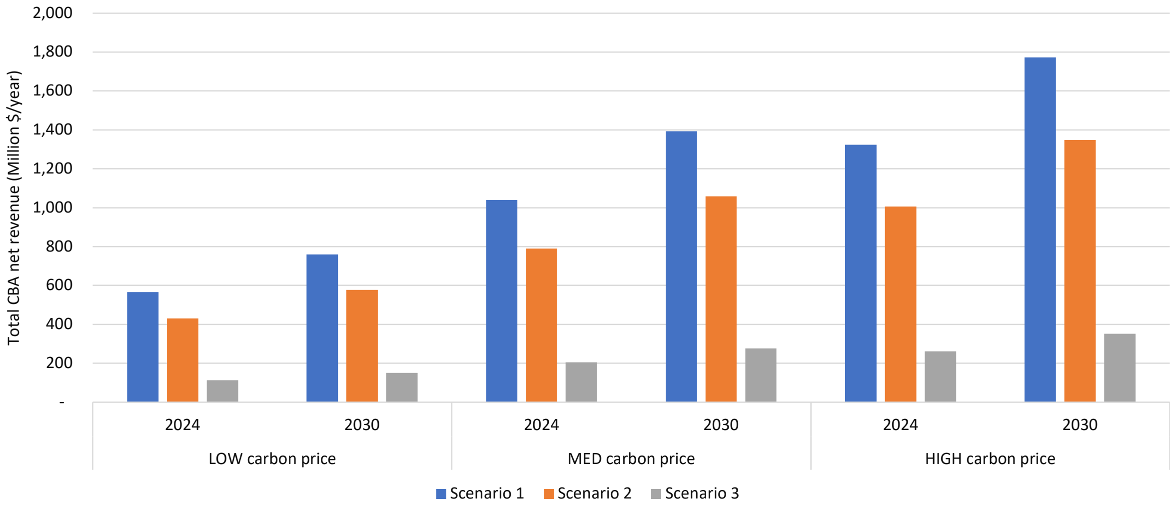


Figure 26. Total annual revenue of BCA for aluminum (import plus net domestic revenue after export rebate) (Million $/year) (Source: this study) .

The ratio of aluminum BCA import revenue to BCA's total revenue varies across scenarios (Table 6). Scenario 2 has the lowest ratio meaning less revenue is generated from an aluminum import carbon fee, and more revenue is generated from the domestic carbon levy under scenario 2. Scenario 3, on the other hand, has the highest ratio of import revenue to total revenue.

Table 6. The ratio of aluminum BCA import revenue to CAB total revenue (Source: this study)

Scenario	The ratio of BCA import revenue to CAB total revenue
Scenario 1	81%
Scenario 2	75%
Scenario 3	84%

Table 6 shows that even if only 75% of the total revenue from a U.S. BCA for aluminum is spent domestically, with the remaining 25% spent internationally to help decarbonize the industry sector in developing countries, it still will put substantially more money back into the U.S. industry than the carbon levy domestic producers will have to pay (The ratio of aluminum BCA import revenue to BCA total revenue is substantially larger than 25%).

The reduction in imported aluminum as a result of U.S. BCA for aluminum under MED carbon price in Scenario 1 is equal to 31% in 2024 and 55% in 2030 of total imported aluminum in the U.S. compared to 2019 level (Figure 27). The reduction in U.S. aluminum imports does not impact the aluminum that the U.S. imports from Canada or Mexico because these two countries meet the carbon intensity threshold. Since Canada and Mexico account for around 84% of the U.S. aluminum export market (USGS 2022a), the direct impact of retaliatory measures by countries that see a reduction in aluminum export to the U.S. is minimal on the U.S. aluminum industry.

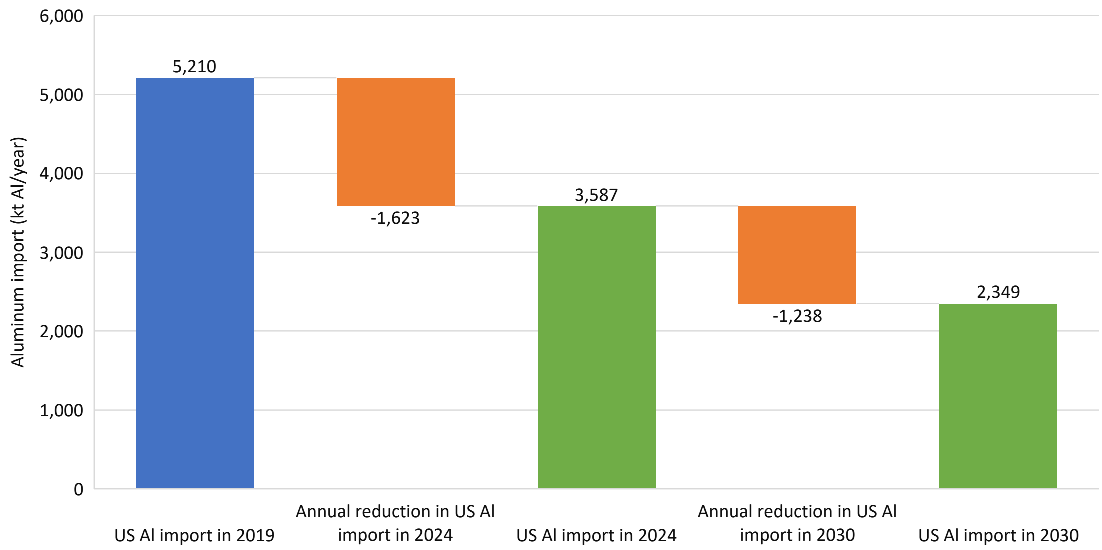


Figure 27. Reduction in annually imported aluminum as a result of U.S. BCA for aluminum under MED carbon price in Scenario 1 (Source: this study) .

The reduction in embodied carbon in imported aluminum as a result of U.S. BCA for aluminum under MED carbon price in Scenario 1 is equal to 44% in 2024 and 59% in 2030 of total embodied CO_2 in imported aluminum in the U.S. compared to 2019 level (figure 28). This is because the weighted average CO_2 intensity of aluminum production in the U.S. (primary and secondary) is substantially lower than that in most other countries from which it imports aluminum.

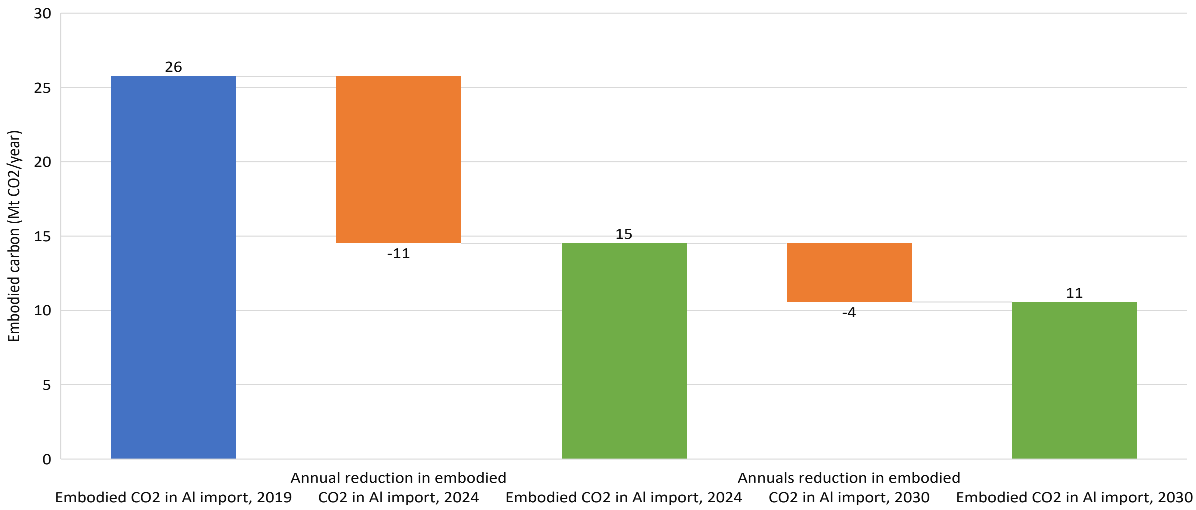


Figure 28. Reduction in annual embodied carbon in imported aluminum as a result of U.S. BCA for aluminum under MED carbon price in Scenario 1 (Source: this study) .

The increase in annual *revenue* of U.S. aluminum companies as a result of reduced U.S. imports from U.S. BCA under MED carbon price in Scenario 1 is around $3,400 million in 2024 and $6,000 million in 2030 (Figure 29). This translate into an increase in the total annual *net profit margin* of the U.S. aluminum companies resulting from the reduced import (Million $), which is estimated to be $ 500 million in 2024 and $ 900 million in 2030, assuming a 15% net profit margin for aluminum producers in the US.

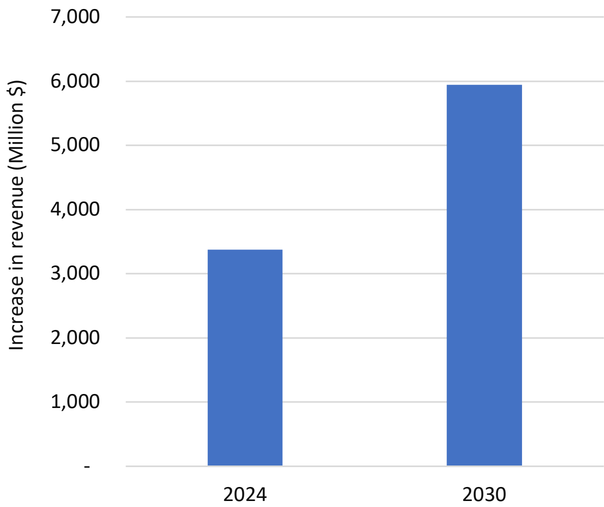


Figure 29. Increase in annual revenue of U.S. aluminum companies as a result of reduced U.S. import from U.S. BCA under MED carbon price in Scenario 1 (Source: this study) .

5.4. Impact of U.S. border carbon adjustment on steel used in passenger cars

In addition to importing steel mills finished and semi-finished steel products, the U.S. also imports a substantial amount of steel-containing products such as automotive, mechanical machinery, electrical equipment, domestic appliances, etc. The embodied carbon in the steel contained in these products can be substantial. Therefore, a potential BCA policy could also target products that contain more than a certain amount of steel. For example, the Clean Competitiveness Act bill proposed in 2022 by Senator Whitehouse proposes that starting in 2026, the proposed BCA policy would be expanded to include imported finished goods containing at least 500 pounds of steel; In 2028, the threshold for coverage would be lowered to 100 lbs.

For this study, we selected passenger cars as an example of steel-containing products to assess the potential impact of a U.S. BCA. This is because automotive import accounts for the largest share of indirect steel import contained in imported products (worldsteel 2015).

The United States imported 5.3 million and exported 2.16 million passenger cars in 2021 (UN Comtrade 2022). Figure 30 shows the top 5 countries that the U.S. imported passenger cars from in 2021, which together accounted for 88% of the U.S. passenger cars imported. Japan, Mexico, and Canada have the largest share of U.S. passenger cars imported.

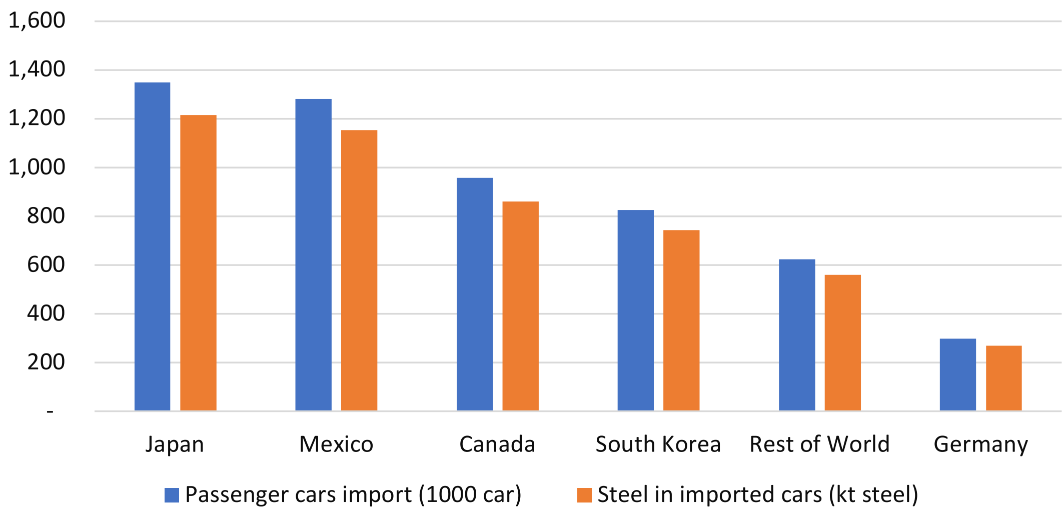


Figure 30. U.S. passenger cars import by country in 2021 (UN Comtrade 2022) .

On average, around 900 kg of steel is used per passenger car (worldsteel 2021). The steel used in car *bodies* is made with about 25 percent recycled steel. Many internal steel parts, however, are made using even higher percentages of recycled steel.

Using the passenger cars trade data and assuming 900 kg of steel is used per passenger car, we estimated the amount of steel used in imported and exported passenger cars in the U.S. in 2021. After that, the rest of the analysis is quite similar to the analysis we explained in section 5.2. for BCA for steel.

Figure 31 shows the annual import revenue of BCA for steel used in passenger cars under different scenarios in Million $/year. Scenario 2 has the highest annual import revenue, but its difference with scenario 1 is not too large. Scenario 1 has a more straightforward approach by using the average CO_2 intensity of steel in each country rather than using an economy-wide intensity for developing countries (scenario 2). Under MED carbon price, the annual import revenue of BCA for steel used in passenger cars ranges from $42 million in scenario 3 to $158 million in scenario 2 in 2024 and from $57 million in scenario 3 to $211 million in scenario 2 in 2030.

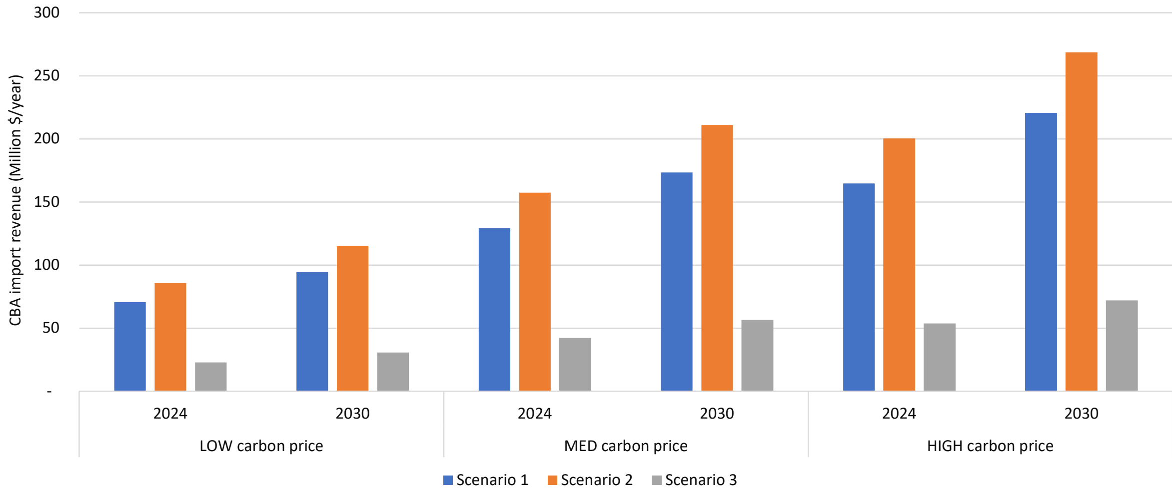


Figure 31. Annual import revenue of BCA for steel used in passenger cars (Million $/year) (Source: this study) .
Scenario 1: Average CO_2 intensity of steel in car manufacturing country is used for steel used in cars. (Has domestic CO_2 price)
Scenario 2: Average CO_2 intensity of steel used for cars imported from developed countries and economy-wide intensity for developing countries (Has domestic CO_2 price)
Scenario 3: Country-specific primary and secondary steel CO_2 intensity are considered separately for steel used in cars (Has domestic CO_2 price)

Like the steel BCA, scenario 3, which uses country-specific primary and secondary steel CO_2 intensity separately, has the lowest annual import revenue potential compared to other scenarios. As explained earlier, this is primarily because the U.S. steel industry's carbon advantage is substantially reduced if the carbon intensity of its primary and secondary steelmaking is compared with that of primary and secondary steelmaking in other countries. However, since 71% of the steel in the U.S. is produced by EAF, which has substantially lower carbon intensity compared to BF/BOF, the weighted average carbon intensity of the steel industry is substantially lower than the average carbon intensity of other countries.

Figure 32 shows the annual import revenue of BCA for steel used in passenger cars in US$ per car. The relative ranking of revenue across scenarios and carbon price levels remains the same as in Figure 31 and for the reasons explained above. Under MED carbon price, the annual import revenue of BCA for steel used in passenger cars ranges from 8 $/car in scenario 3 to 30 $/car in scenario 2 in 2024 and from 11 $/car in scenario 3 to 40 $/car in scenario 2 in 2030 under different scenarios. These BCA import charges per car shown in Figure 32 are negligible compared with an average selling price of a new passenger car of over $42,000 in the U.S. in 2021 (Statista 2022b). Therefore, a U.S. BCA for steel used in passenger cars will likely not have any trade implication in terms of a reduction in passenger cars import.

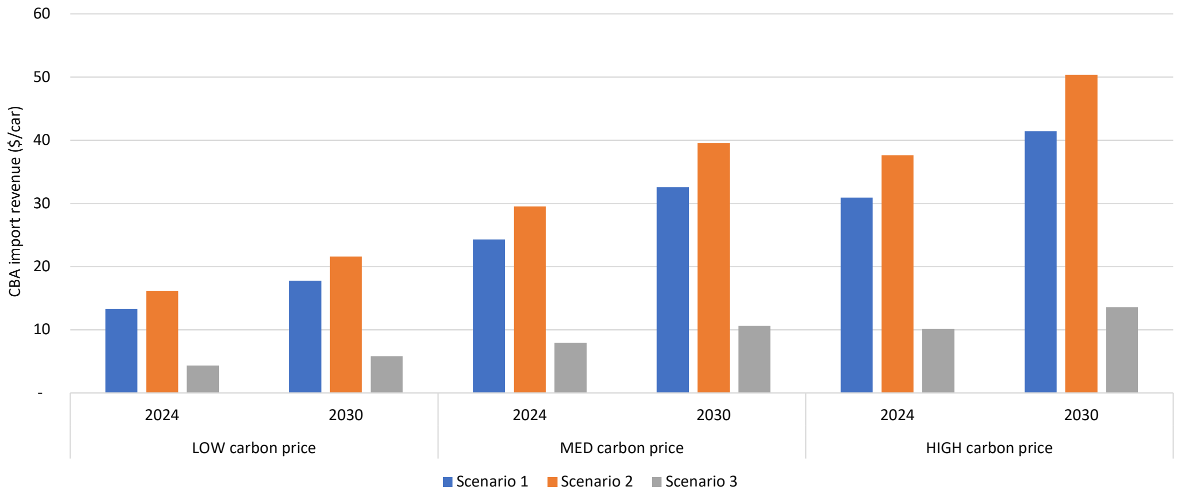


Figure 32. Annual import revenue of BCA for steel used in passenger cars ($/car) (Source: this study) .

Scenario 1: Average CO_2 intensity of steel in car manufacturing country is used for steel used in cars. (Has domestic CO_2 price)

Scenario 2: Average CO_2 intensity of steel used for cars imported from developed countries and economy-wide intensity for developing countries (Has domestic CO_2 price)

Scenario 3: Country-specific primary and secondary steel CO_2 intensity are considered separately for steel used in cars (Has domestic CO_2 price)

After adding the domestic revenue from the carbon levy paid by domestic car producers for the portion of steel used in the car with the carbon intensity above the U.S. baseline (see section 5.1.) and deducting the export rebate paid to U.S. car exporters, we calculated the total annual revenue of BCA for steel used in passenger cars (Figure 33). Scenario 2 has the highest *total annual* revenue of BCA for steel used in passenger cars. Under MED carbon price, the total annual revenue of BCA for steel used in passenger cars ranges from $39 million in scenario 3 to $144 million in scenario 2 in 2024 and from $52 million in scenario 3 to $193 million in scenario 2 in 2030.

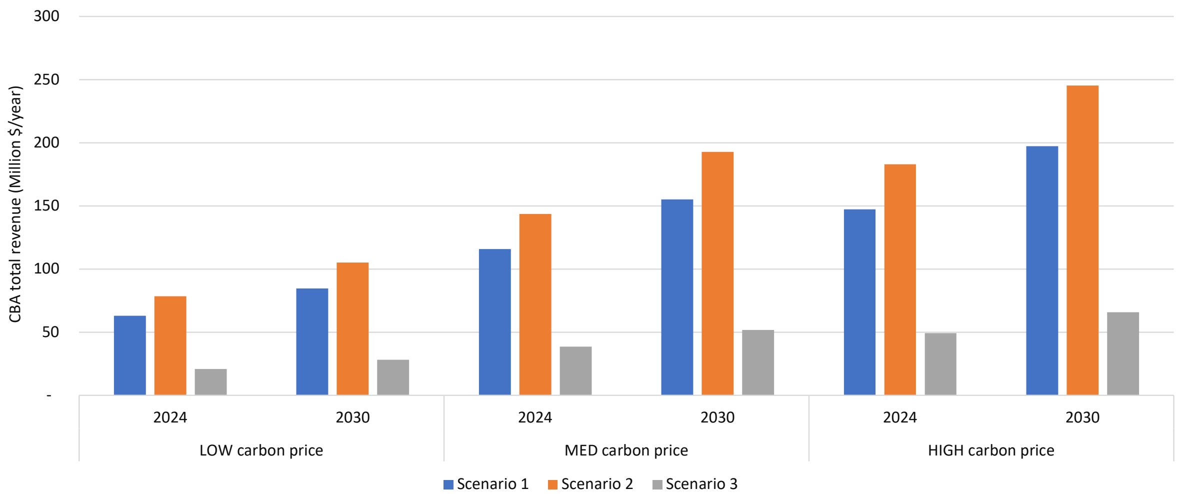


Figure 33. Total annual revenue of BCA for steel used in passenger cars (import plus net domestic revenue after export rebate) (Million $/year) (Source: this study) .

6 Border Carbon Adjustment Policy Design Considerations

This section discusses some of the key policy design considerations for designing and implementing a successful BCA policy. BCAs must be designed to advance climate objectives and not be misused as a tool to enhance protectionism, unjustifiable discrimination, or restrictions (Oharenko, 2021).

Step 1: Identify objectives

Overall, one objective of a BCA is to allow instruments (like carbon pricing) to reduce emissions by preventing the leakage that they would otherwise encourage. This achieves another integral goal of ensuring domestic competitiveness with cheaply produced foreign goods while also discouraging them from outsourcing to countries with less oversight. Domestically, countries can do this by targeting carbon-intensive goods and industries and instituting a cap on emissions levels, a carbon tax, or outright prohibiting or phasing out these industries. These are not considered BCAs as they are domestic policies applied inside the borders and not at them. However, countries can do little to control the regulations on production in other countries, even if the producers are based in the first country but produce in another. Arising from this is the issue of carbon leakage. This imposes a heavier financial and logistical burden on domestic producers due to regulations that foreign producers are not subject to. A BCA would be a vital policy tool to reduce leakage to the maximum extent possible. This spurs international firms to maintain lower carbon levels to avoid the tax or face an excise tax at the border, raising costs to equate to those of domestic production.

Step 2: Determine targets

Domestic carbon pricing

A BCA arises to reduce carbon leakage due to domestic carbon pricing. Without a carbon price levied on domestic production to maintain a low level of industrial emissions, the imposition of a carbon tax on imports may be against World Trade Organization (WTO) rules and also discourage foreign trade. Domestic carbon pricing is often done through a cap-and-trade system, like the EU's emissions trading system (ETS). Nevertheless, there are some groups that advocate BCA but argue that domestic carbon pricing is not necessary and, instead, other climate regulations and spending could be considered as the basis for imposing BCA.

Value-added tax/rebate and calculation

The main function of a BCA is to subject goods from countries with less stringent climate regulations to a country's domestic carbon pricing to decrease leakage. Goods exported from the pricing country will receive a rebate. Each policy will have a defined calculation for determining how carbon-intensive specific goods are and what tariff they will be subject to. Such a system will deter domestic producers from relocating to countries with less stringent regulations and keep them on an even footing.

Step 3: Establish tax base and enforcement mechanisms

Defined items

The policy must lay out which items will be subject to a BCA. These items do not have to be finished materials but can also apply to goods in the process of being made, such as crude steel and aluminum. Some examples of carbon-intensive industries that may be at a higher risk for carbon leakage are steel, aluminum, fertilizer, cement, electricity, glass, paper, and more. These defined items make up the carbon border tax base. The wider the tax base, the less likely the leakage. Furthermore, as industries adapt to a carbon-neutral future, new items may be added or subtracted from the list based on their carbon intensities and their risk of carbon leakage.

Timeline

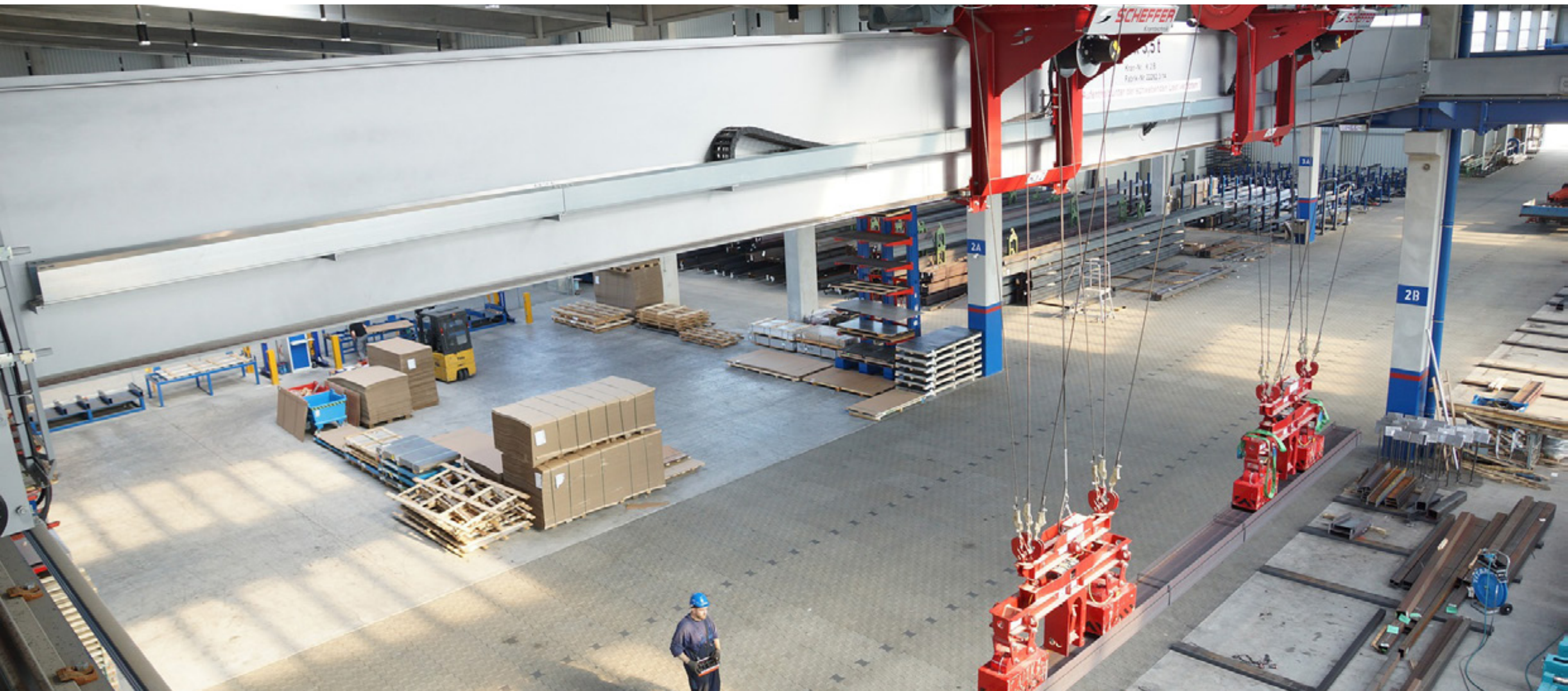
A BCA will need a structured timeline for its implementation. As the price of carbon continues rising as we move towards 2050, there will be defined raises in the carbon border tax over time, typically in yearly increments. The timeline may also define the level of emissions permitted, which may decrease as net-zero becomes a feasible reality. For example, the proposed Clean Competition Act in the U.S. would impose a 2.5% annual decrease in emissions baseline until 2028 and a 5% annual decrease thereafter, requiring all producers to stay under this threshold to avoid the BCA. The EU seeks to implement its "Fit for 55" policy goal to reduce its emissions by 55% by 2030, a highly ambitious target that the EU's CBAM policy plays a critical role in achieving (European Council, 2022).

Enforcement

The enforcement of the carbon fee should not be overly protectionist to discourage trade but should also reward the domestic producers for their compliance. It should also be designed so that countries with equally or more stringent carbon pricing are not negatively impacted by such a policy when their goods are imported. There are several possible ways to enforce a BCA, varying in complexity. The currently proposed CBAM in the EU would require EU companies that are importing a good into the EU to purchase emissions credits to cover the level of emissions embodied in the imported goods. These reforms to the EU ETS, coupled with an aggressively decreasing cap on emissions, aim to drastically reduce the carbon footprint of goods produced in and entering Europe (European Council, 2022). Another option that would work better for some countries than others is to require detailed and verifiable data on the carbon footprint of goods. Several countries, such as the United States, have existing emissions caps and mandate accurate reporting of companies' manufacturing processes. Unfortunately, this is not the case for most countries around the world, especially in developing economies, and may not be a worthwhile method of enforcement at the border. Participation in this BCA would be compulsory, as it is requisite for goods to enter a country.

Step 4: Measure the impact on trade, carbon, and policy

A BCA policy has the potential to be a commonplace economic mechanism in the fight against climate change within the next decade. There is already evidence pointing toward the impending success of the EU's CBAM policy; the revisions to their ETS policy would nearly double the percentage decrease of annual emissions and increase carbon tax revenue from the EU CBAM due to an expanded industrial base (European Council, 2022). It should also lead to significantly decreased emissions as time goes on. Furthermore, while it may not be explicitly stated in the policy, a BCA implementation inherently increases international cooperation on emissions reductions. If countries with large economies impose a BCA on imports, this not only incentivizes emissions reductions among private companies to avoid an excise tax but also encourages allied or friendly countries to align their policy positions accordingly.



7 Trade Implications of a U.S. Border Carbon Adjustment

The original authentic text of the United Nations Framework Convention on Climate Change (UNFCCC) states that “measures taken to combat climate change should not constitute unjustifiable discrimination or a disguised restriction on international trade.” The UNFCCC statement highlights the synergies and tensions between trade and climate policy. A BCA exemplifies the unions and tensions between trade and climate policy. While climate policies may breach trade rules, unilateral and multilateral trade policies may influence how countries design their respective climate policies (Prag, 2020).

Implications of Border Carbon Adjustment on trade agreements
The BCA policy has serious implications for trade relationships/agreements involving developing and developed countries. Its impact is associated with bilateral, multilateral, and WTO trade agreements. Introducing a BCA changes trade patterns in favor of countries with carbon-efficient production (i.e., a decline in exports from developing countries in favor of developed countries because developed countries tend to have less carbon-intensive production processes) (United Nations Conference on Trade and Development, 2021). However, if the export rebate and import tax are equal to the domestic tax in the Border Carbon Adjustment program, BCA is theoretically trade-neutral; thus, it does not encourage or discourage trade (Auerbach, 2016). Nonetheless, there is concern that implementing the BCA policy could lead to retaliatory tariffs or trade wars.

To be successful, a BCA must be accompanied by multilateral and bilateral cooperation initiatives regarding climate mitigation and carbon emissions reduction. Bilateral trade agreements are agreements between countries to promote trade. Such agreements eliminate trade barriers such as tariffs, import quotas, and export restraints to encourage trade. An example of such a multilateral initiative is the G7 Climate Club which was one of the key outcomes of the latest G7 summit in June 2022 (G7 Germany 2022). In its official statement, the Club builds on the insufficient global climate ambition and implementation and aims to meet the climate goals of the Paris Agreement by accelerating climate actions. The Club notes its attention to addressing the issues of carbon loophole and carbon leakage.

Another example of this is the U.S.- EU Carbon-Based Sectoral Arrangement on Steel and Aluminum Trade (The White House 2021b). Research on bilateral trade reveals that regions with a BCA on their international climate agenda, such as the EU, significantly increase intra-regional trade (among EU member nations). In contrast, all other regions lessen trade with the EU while increasing trade with other regions. Thus, the EU CBAM can appear to have the effect of a tariff increase by a trading bloc, increasing intra-bloc trade and rerouting trading partners’ trade to other regions (United Nations Conference on Trade and Development, 2021). The proliferation of intra-regional trade and the decrease in trade with foreign countries are unfortunate consequences that must be reversed by careful cooperation within BCA policies.

Trading via a climate-conscious policy with only regional members is insufficient because the global climate crisis requires a response from united international action. Although bilateral trade is essential in other cases, dramatically reducing carbon emissions through trade policy necessitates widespread multilateral trading. Multilateral trade agreements are established between three or more countries to minimize trade barriers such as tariffs, subsidies, and embargoes. A flexible BCA policy that exhibits diverse policy techniques to mitigate climate change should be seen as multilateral unilateralism, especially when taking into account the widespread ratification of the Paris Agreement among WTO member states. Although BCA tariffs might be unilateral since they represent an individual nation's actions, they should be viewed as multilateral since they are a component of the widespread commitment to reduce GHG emissions expressed in the 2015 Paris Agreement and the 2021 Glasgow Climate Pact (Dominioni & Esty, 2022).

The agreements within the WTO, a crucial global trade regulator, cover goods and detail the liberalization principles and permitted exceptions. Such agreements include individual countries' commitments to lower customs tariffs and other trade barriers and maintain open markets (WTO 2022). The WTO requires that countries do not unjustifiably discriminate against goods from other countries in favor of domestic producers (national treatment test) or favor imports from specific member countries over others (most-favored-nation treatment) (Condon & Ignaciuk, 2013). The WTO agreements that apply to a BCA policy are different for imports and exports. The General Agreement on Tariffs and Trade (GATT) limits how WTO members impose taxes on imports and forbids discrimination among member countries. The Subsidies and Countervailing Measures (SCM) agreement prohibits countries from subsidizing exported goods (Trachtman, 2016). It is paramount that BCAs are compatible with WTO rules and free trade agreements.

Trade barriers/issues facing EU CBAM for the U.S. steel and aluminum industry and potential solutions

Although several of the EU's trading partners exporting steel and aluminum goods have raised concerns that the CBAM would considerably curtail their exports and the fee would be discriminatory against their products, others have expressed interest in the carbon import fee based on carbon emissions (UNCTAD, n.d.). A trading partner's sentiment toward the BCA is dependent on the carbon intensity of their processes and decarbonization potential. To minimize its trade effects, the European Commission initially had CBAM apply to imports in only five emissions-intensive sectors at greater risk of carbon leakage; two of the five sectors are iron and steel, and aluminum. The EU CBAM would provide an incentive for steel and aluminum producers to cut emissions, most likely until the marginal cost of doing so equals the carbon cost of the CBAM.

Our analysis of the carbon intensity of steel production in various countries illustrates the differential impact of the tariff (Hasanbeigi 2022). Steel imported from more carbon-intensive producers will become more expensive than steel from less carbon-intensive manufacturers, as shown earlier in this report. Although U.S. steel has lower carbon intensity than most other countries and thU.S. would have lower carbon charges under EU CBAM, U.S. steel is still not clean enough for the EU's future climate mitigation plans.

Furthermore, the CBAM could significantly impact the global supply chain for aluminum due to the significant differences in carbon intensity among producing countries (Hasanbeigi et al., 2022). While the U.S. is the second-largest importer of aluminum behind the EU, its export is much smaller, with over 80% of its export going to Canada and Mexico. Therefore, the U.S. aluminum industry is less sensitive to the EU's CBAM (Climate Advisers, 2021). Also, the CBAM would likely raise the price for aluminum products imported from countries dependent on high carbon-emitting energy sources like coal. In contrast, countries with lower-emitting energy sources, such as hydropower and natural gas, would have lower prices (Matthews, 2020).

A potential solution to the potentially high import tax that the U.S. steel and aluminum industry might face under EU CBAM policy is implementing a matching BCA/carbon price of its own. A matching BCA/carbon price would excuse the U.S. steel and aluminum industries from paying the EU's CBAM tariff, reduce their carbon emissions, and avoid harming the trade of U.S. industries. Solutions that decarbonize the industries would improve their trade competitiveness and eliminate trade barriers.

Trade considerations in the EU's CBAM program

The EU's CBAM will level the playing field of international trade and climate policy, allowing nations to move forward with ambitious climate policies without worrying about competitiveness losses (Campbell et al., 2021). The desired global reach of CBAM entails trade complexities, thU.S. meaning it will undergo revisions and take trade considerations seriously to secure its success. The Committee on International Trade (INTA) provides inputs on the compatibility with WTO rules and existing EU free trade agreements (Karlsbro, 2021). Its recommendations are an opportunity for the advantageoU.S. transformation of the initial CBAM proposal.

In the justification of the INTA's draft opinion for ENVI on the EU CBAM proposal, INTA expresses the need for the EU to show the world that growth, sustainable trade, and openness can coexist with significant carbon emission reductions. Additionally, the INTA states that the EU must initiate global multilateral cooperation on carbon reduction and support the least developed countries to make the green transition possible. A fair CBAM must ensure its efficiency and conformity with international trade agreements. The CBAM must be as easy to use/accessible as possible and must not create excessive trade barriers; therefore, it cannot be identical to EU ETS. Ideally, the EU CBAM would be applied to all emissions covered by the EU ETS. However, given the complexity of setting up a system with no prior example to emulate and the importance of not unnecessarily disrupting trade flows, it is reasonable to limit the CBAM to only the most carbon-intensive sectors and their direct emissions in the first stage. Once the system's efficiency improves and matures after its implementation, the European Commission will assess how to best expand the impact of CBAM (Karlsbro, 2021).

The BCA must be a tool to advance sustainable rules-based trade. The governments must maintain dialogue and open consultation with various participating countries to avoid the BCA being viewed as a protectionist policy and eventually leading to trade wars. Only with openness and multilateral cooperation will we find the most efficient way to reduce global carbon emissions.

References

Auerbach, Alan J. (December, 2016) “The Role of Border Adjustments in International Taxation.” https://eml.berkeley.edu/~auerbach/The%20Role%20of%20Border%20Adjustments%20in%20International%20Taxation%2012-2-16-1.pdf

Bernasconi-Osterwalder, N., & Cosbey, A. (2021, May 18). Carbon and Controversy: Why we need global cooperation on border carbon adjustment. International Institute for Sustainable Development. https://www.iisd.org/articles/carbon-border-adjustment-global-cooperation

Bray, S., & Muresianu, A. (2022, July 8). Carbon taxes in the global market: Changes on the way? Tax Foundation. Retrieved August 16, 2022, from https://taxfoundation.org/BCA-carbon-price-tariffs/

Campbell, E., McDarris, A., & Pizer, W. (2021, November 10). Border Carbon Adjustments 101. Resources for the Future. https://www.rff.org/publications/explainers/border-carbon-adjustments-101/#:~:text=Benefits%20of%20a%20Border%20Carbon,the%20threat%20of%20competitiveness%20losses.

Center for American Progress (CAP). 2022. How the Inflation Reduction Act Will Drive Global Climate Action. https://www.americanprogress.org/article/how-the-inflation-reduction-act-will-drive-global-climate-action/

Climate Advisers. (2021). What the EU’s BCA Means for the United States. Climate Advisers. https://www.climateadvisers.org/2021/07/22/what-the-eus-BCA-means-for-the-united-states/

Climate Leadership Council (2021). (rep.). Leveraging a Carbon Advantage: Impacts of a Border Carbon Adjustment and Carbon Fee on the U.S. Steel Industry (pp. 1–7). Washington, DC.

Condon, M. and A. Ignaciuk (2013), “Border Carbon Adjustment and International Trade: A Literature Review,” OECD Trade and Environment Working Papers, No. 2013/06, OECD Publishing, Paris, https://doi.org/10.1787/5k3xn25b386c-en.

Cosbey, A. (2021, September 27). Principles and best practice in Border Carbon Adjustment. International Institute for Sustainable Development. Retrieved August 16, 2022, from https://www.iisd.org/articles/principles-border-carbon-adjustment-modest-proposal

Cosbey, A., Mehling, M., & Marcu, A. (2021). Border Carbon adjustments in the EU: Sectoral deep dive. SSRN Electronic Journal, 1–77. https://doi.org/10.2139/ssrn.3817779

Council agrees on the Carbon Border Adjustment Mechanism (BCA). (2022, March 15). Council of the European Union. Retrieved from https://www.consilium.europa.eu/en/press/press-releases/2022/03/15/carbon-border-adjustment-mechanism-BCA-council-agrees-its-negotiating-mandate/.

Dominioni, G., & Esty, D. (2022, April 22). Designing an effective Carbon Border Adjustment Mechanism. Centre for Economic Policy Research. https://voxeu.org/article/designing-effective-border-carbon-adjustment-mechanism

EU should consider the trade impacts of new climate change mechanism. UNCTAD. (2021, July 14). https://unctad.org/news/eu-should-consider-trade-impacts-new-climate-change-mechanism

European Council. (2022, July 29). Fit for 55: Reform of the EU emissions trading system. Consilium. Retrieved August 16, 2022, from https://www.consilium.europa.eu/en/info-graphics/fit-for-55-eu-emissions-trading-system/

European Council. (2022, June 30). Fit for 55. Consilium. Retrieved August 16, 2022, from https://www.consilium.europa.eu/en/policies/green-deal/fit-for-55-the-eu-plan-for-a-green-transition/

Figures, T., Gilbert, M., McAdoo, M., & Voigt, N. (2021, October 12). The EU's Carbon Border Tax Will Redefine Global Value Chains. BCG Global. https://www.bcg.com/publications/2021/eu-carbon-border-tax

G7 Germany. 2022. G7 Statement on Climate Club.

Hasanbeigi, A. 2022. Steel Climate Impact — An International Benchmarking of Energy and CO_2 Intensities. Global Efficiency Intelligence. Florida, United States.

Hasanbeigi, A., Springer, C., Shi, D. 2022. Aluminum Climate Impact — An International Benchmarking of Energy and CO_2 Intensities. Global Efficiency Intelligence. Florida, United States.

Hasanbeigi, A.; Darwili, A.. 2022. Embodied Carbon in Trade: Carbon Loophole. Global Efficiency Intelligence. Florida, United States.

H.R.5376 - 117th Congress (2021-2022): Inflation Reduction Act of 2022. (2022, August 16). http://www.congress.gov/

IEA. 2020c. Global CO_2 emissions in 2019. https://www.iea.org/articles/global-co2-emissions-in-2019

International Aluminium Institute. 2022. "Primary Aluminium Production." https://international-aluminium.org/statistics/primary-aluminium-production/

International Aluminum Institute (IAI). 2021. Beyond 2 Degrees Aluminum Sector Data Sheet.

Kardish, C., Ye, J, Keohane, N. 2022. Carbon Border Adjustments: Considerations for Policymakers. Center for Climate and Energy Solutions.

Karlsbro, Karin. (2021). DRAFT OPINION of the Committee on International Trade for the Committee on Environment, Public Health and Food Safety on the proposal for a regulation of the European Parliament and of the Council establishing a Carbon Border Adjustment Mechanism. Committee on International Trade. https://www.europarl.europa.eu/doceo/document/INTA-PA-699250_EN.pdf

Koester, S., Sly, G., & Hart, D. M. (2021, September 20). Unworkable Solution: Carbon Border Adjustment Mechanisms and Global Climate Innovation. Information Technology and Innovation Foundation. https://itif.org/publications/2021/09/20/unworkable-solution-carbon-border-adjustment-mechanisms-and-global-climate

Leith, D., Turnsek, A., & Hopkins, A. (n.d.). UK Parliamentary Committee calls for development of UK Carbon Border Policy. EY. Retrieved August 16, 2022, from https://www.ey.com/en_gl/tax-alerts/uk-parliamentary-committee-calls-for-development-of-uk-carbon-border-policy

Matthews, Daniel. (2020). Carbon Border Adjustments: A Catalyst for Lower Aluminum Industry Emissions? U.S. International Trade Commission. https://www.usitc.gov/publications/332/executive_briefings/ebot_primary_aluminum_emissions.pdf

Melin, Y., Vandenberghe, W., Heeren, P., & Kim, J. W. (2021, December 17). Five key things about the EU's Carbon Border Adjustment Mechanism | Perspectives. Reed Smith LLP. Retrieved August 16, 2022, from https://www.reedsmith.com/en/perspectives/2021/12/five-key-things-about-the-eus-carbon-border-adjustment-mechanism

Office of Senator Sheldon Whitehouse, United States Senate. (2022). Whitehouse and Colleagues Introduce Clean Competition Act to Boost Domestic Manufacturers and Tackle Climate Change. Retrieved from https://www.whitehouse.senate.gov/news/release/whitehouse-and-colleagues-introduce-clean-competition-act-to-boost-domestic-manufacturers-and-tackle-climate-change.

Oharenko, Y. (2021, May 17). An EU Carbon Border Adjustment Mechanism: Can it Make Global Trade Greener While Respecting WTO Rules? SDG Knowledge Hub. https://sdg.iisd.org/commentary/guest-articles/an-eu-carbon-border-adjustment-mechanism-can-it-make-global-trade-greener-while-respecting-wto-rules/

Pomerleau, S. (2020). (issue brief). Border Adjustments in a Carbon Tax (pp. 1–16). Washington, DC.

Prag, Andrew. (2020). The Climate Challenge and Trade: Would border carbon adjustments accelerate or hinder climate action? OECD. https://www.oecd.org/sd-roundtable/papersandpublications/The%20Climate%20Challenge%20and%20Trade...%20background%20paper%20RTSD39.pdf

Siegel, J. (2021, May 26). How the U.S. Steel Industry could benefit from a carbon tax and 'border adjustment'. Climate Leadership Council. https://clcouncil.org/media-coverage/how-the-us-steel-industry-could-benefit-from-a-carbon-tax-and-border-adjustment/

Statista. 2022a. Import and export volume of unwrought aluminum and aluminum alloys worldwide from 2005 to 2021. https://www.statista.com/statistics/491244/global-import-export-unwrought-aluminum-alloy-timeline/

Statista. 2022b. New vehicle average selling price in the United States from 2016 to 2021. https://www.statista.com/statistics/274927/new-vehicle-average-selling-price-in-the-united-states/

Trachtman, Joel. "WTO Law Constraints on Border Tax Adjustment and Tax Credit Mechanisms to Reduce the Competitive Effects of Carbon Taxes." (January 2016) https://media.rff.org/documents/RFF-DP-16-03.pdf

The White House. 2022. FACT SHEET: Biden-Harris Administration Announces New Buy Clean Actions to Ensure American Manufacturing Leads in the 21st Century.

The White House. 2021a. FACT SHEET: President Biden Sets 2030 Greenhouse Gas Pollution Reduction Target Aimed at Creating Good-Paying Union Jobs and Securing U.S. Leadership on Clean Energy Technologies

The White House. 2021b. FACT SHEET: The United States and European Union To Negotiate World's First Carbon-Based Sectoral Arrangement on Steel and Aluminum Trade.

U.S. Geological Survey. 2022a. Steel Statistics and Information. https://www.usgs.gov/centers/national-minerals-information-center/iron-and-steel-statistics-and-information

U.S. Geological Survey. 2022b. Aluminum Statistics and Information. https://www.usgs.gov/centers/nmic/aluminum-statistics-and-information

UN Comtrade. 2022. International Trade Statistics Database. https://comtrade.un.org/

WTO. 2022. Understanding the WTO: The Agreements. https://www.wto.org/english/thewto_e/whatis_e/tif_e/agrm1_e.htm#:~:text=The%20WTO%20agreements%20cover%20goods,and%20keep%20open%20services%20markets

United Nations Conference on Trade and Development. (2021). A European Union Carbon Border Adjustment Mechanism: Implications for developing countries. United Nations Conference on Trade and Development. https://unctad.org/system/files/official-document/osginf2021d2_en.pdf

Worldsteel Association. 2015. Indirect trade in steel.

Worldsteel Association. 2021. Steel in automotive.

Worldsteel Association. 2021. Steel statistical yearbook 2020.

Worldsteel Association. 2022. World steel in figures.

Appendices

Appendix 1. Economy-wide carbon intensity of countries

Table A.1 economy-wide carbon intensity used in our analysis (WIOD 2022) .

Country	Economy-wide carbon intensity	
	kg CO_2/2015$ GDP	Ratio to the U.S.
Argentina	0.39	1.68
Belgium	0.17	0.75
Brazil	0.23	1.00
Canada	0.33	1.43
China	0.74	3.16
France	0.11	0.48
Germany	0.18	0.78
Japan	0.22	0.94
South Korea	0.38	1.64
Mexico	0.36	1.53
Netherlands	0.17	0.71
Russia	0.98	4.21
Spain	0.18	0.79
Sweden	0.07	0.29
Taiwan	0.38	1.64
Turkiye	0.54	2.32
United Kingdom	0.13	0.54
Vietnam	0.86	3.71
Other	0.39	1.68
United States	0.23	1.00
Argentina	0.39	1.68
Australia	0.28	1.19
Austria	0.14	0.61
Bahrain	0.80	3.42
India	0.87	3.72
Indonesia	0.52	2.21
Oman	0.86	3.69
South Africa	1.12	4.81
UAE	0.42	1.82
Venezuela	0.42	1.82
Rest of World	0.39	1.68