# OUTPUT-BASED REBATES: AN ALTERNATIVE TO BORDER CARBON ADJUSTMENTS FOR PRESERVING US COMPETITIVENESS

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## Executive Summary

Two linked and frequently raised concerns about putting a price on carbon dioxide emissions in the United States are whether such a tax would unintentionally advantage foreign competitors and, as a result, lead to increased emissions outside American borders. The tax could make American products more expensive than those made by companies in countries not imposing comparable climate regulations, which could lead to shifts in production overseas. Because a central aim of climate policy is to reduce global emissions, the "leakage" of production overseas would run counter to this goal. To avoid this outcome, carbon tax proposals commonly include a border carbon adjustment (BCA), which would impose the carbon tax on imported energy-intensive and trade-exposed products and provide a tax refund for exports of the same products.

This commentary, part of a series of joint research on carbon tax policies by Columbia University's Center on Global Energy Policy and Rhodium Group, highlights an alternative way to ensure that US firms remain on a level playing field with foreign competitors: output-based rebates (OBRs). While a BCA would focus on imports and exports, an OBR would instead compensate vulnerable US firms based on their production—a simpler process. Both BCAs and OBRs have their benefits and drawbacks, but nearly all carbon tax bills recently proposed in Congress included a BCA, and none included OBRs. This commentary reintroduces output-based rebates as an alternative to BCAs, analyzes US industries that could be compensated with OBRs, and estimates the costs of doing so.

A border carbon adjustment is an appealing concept: simply apply the same carbon tax to foreign firms that is applied to domestic firms. The key advantage of OBRs is avoiding the most significant administrative hurdles of BCAs, including the complexities of determining the carbon content of foreign goods and providing foreign firms credit for climate regulations in their home countries.

The proposed (but not passed) American Clean Energy and Security Act of 2009, commonly called the Waxman-Markey climate bill, included compensation for energy-intensive and trade-exposed (EITE) US firms with OBRs. This commentary uses the

Waxman-Markey proposal as a guidepost to analyze the potential scope and costs of OBRs today. The results show:

- While 46 industries would have been eligible for OBRs under Waxman-Markey, using the same thresholds for EITE industries, just 14 industries would be eligible today. The single biggest driver of this change is the fall in energy prices that has lowered the energy intensity of these US industries.
- Waxman-Markey would have granted OBRs to industries with annual carbon dioxide emissions of 731 million metric tons in 2006; those same industries emitted 496 million metric tons in 2018. Using the Waxman-Markey thresholds, the 14 industries that would still be eligible today emitted 174 million metric tons of $CO_2$ in 2018.
- The annual cost of OBRs could range from 3 to 10 percent of the revenue from a carbon tax (roughly $4 to $13 billion per year for a $25 per ton carbon tax), depending on which industries are covered by the program.

Policy makers designing OBRs would need to carefully balance trade-offs associated with industry eligibility and the structure and level of compensation. They should also be wary of unintended consequences like providing additional support for polluting facilities near disadvantaged communities.

## Introduction

Experts have long recommended a price on carbon throughout the economy as an important part of a comprehensive climate change strategy. Eleven carbon pricing policies have been proposed in the US Congress in 2019 and 2020.

However, unilaterally imposing a carbon tax raises concerns about the competitiveness of businesses in certain domestic industries. Some domestic firms that pay a carbon tax as part of their production costs are unable to pass on some or all of those costs to customers in the form of higher product prices. This situation is most likely to occur for producers that have a relatively high carbon cost of production and compete against foreign companies that are not subject to comparable regulations from their own governments (these industries are commonly referred to as energy-intensive and trade-exposed [EITE] industries). Without a remedy, firms may reduce or eliminate production of such products, potentially ceding market share, or they may flee the country and resume production elsewhere (offshoring). Thus, emissions would decline in the United States but increase somewhere else in the global economy, which is one (but not the only[1]) important source of "emissions leakage.

Fortunately, there are several ways to avoid these adverse outcomes by combining a carbon tax with a mechanism that levels the playing field for domestic firms while retaining incentives to reduce emissions.

From the starting point of a national carbon tax, putting domestic and foreign firms on equal footing requires increasing costs for foreign producers, reducing costs for domestic producers, or both. This analysis looks at two major policy tools that accomplish this:

- Border carbon adjustments (BCAs), which impose a fee on imported energy-intensive and trade-exposed products and a refund for exports of the same products.
- Output-based rebates (OBRs), which consist of payments to energy-intensive and trade-exposed firms based on their production.

Of the 11 carbon pricing policies that have been introduced in the current US Congress (ten carbon taxes and one cap-and-trade program)[2], all but one include a BCA. None of these proposals includes OBRs.

The purpose of this commentary is to discuss OBRs as an alternative to BCAs for addressing competitiveness and leakage concerns alongside a carbon price. The piece explains why policy makers may wish to consider an alternative to a BCA, and it describes OBRs and how they compare to BCAs across various metrics. Finally, an analysis covers what OBRs might entail in practice, including the industries likely to receive rebates and how much such a program might cost.

## Challenges Surrounding the Effectiveness and Administrability of BCAs

The near-universal adoption of BCAs in recent carbon pricing proposals[3] may give the impression of a widespread consensus that BCAs *should* be included in carbon pricing legislation. But the extensive literature on BCAs tells a more nuanced story. It points to a BCA as an elegant and perhaps *theoretically* optimal approach to addressing concerns that the unilateral adoption of a carbon price could harm domestic competitiveness and cause emissions leakage. But the literature also notes the serious challenges of successfully implementing BCAs,[4] without a consensus on whether these challenges can be sufficiently overcome.

Specifically, the literature suggests at least three major challenges.

First, while in theory a BCA would tax imports and provide a rebate to exports based on carbon intensity, in reality, a BCA would only apply to a small subset of imports and exports because it would be administratively infeasible to apply the BCA to thousands of internationally traded products.[5] But application to only a portion of products would create unintended consequences; for example, if a BCA covers imports of steel but not imports of cars made with steel, then it might provide an incentive to shift car manufacturing outside of the United States.[6]

A second challenge is determining the carbon content of the imported products covered by the BCA. It would be difficult to estimate the actual carbon content of every product, and, even if that were possible, foreign producers could sell their cleaner products in the United States and their dirtier products in markets with less stringent regulations. To provide the right incentives, the fee should ideally be assessed based on the total emissions caused by the production of the specific imported product at a given time, but that depends on the characteristics of the exporting country's energy system and is probably not administratively feasible to determine.[7] Some scholars have proposed an imperfect middle ground, whereby foreign products are charged based on the average carbon intensity of a firm's production in each exporting country.[8]

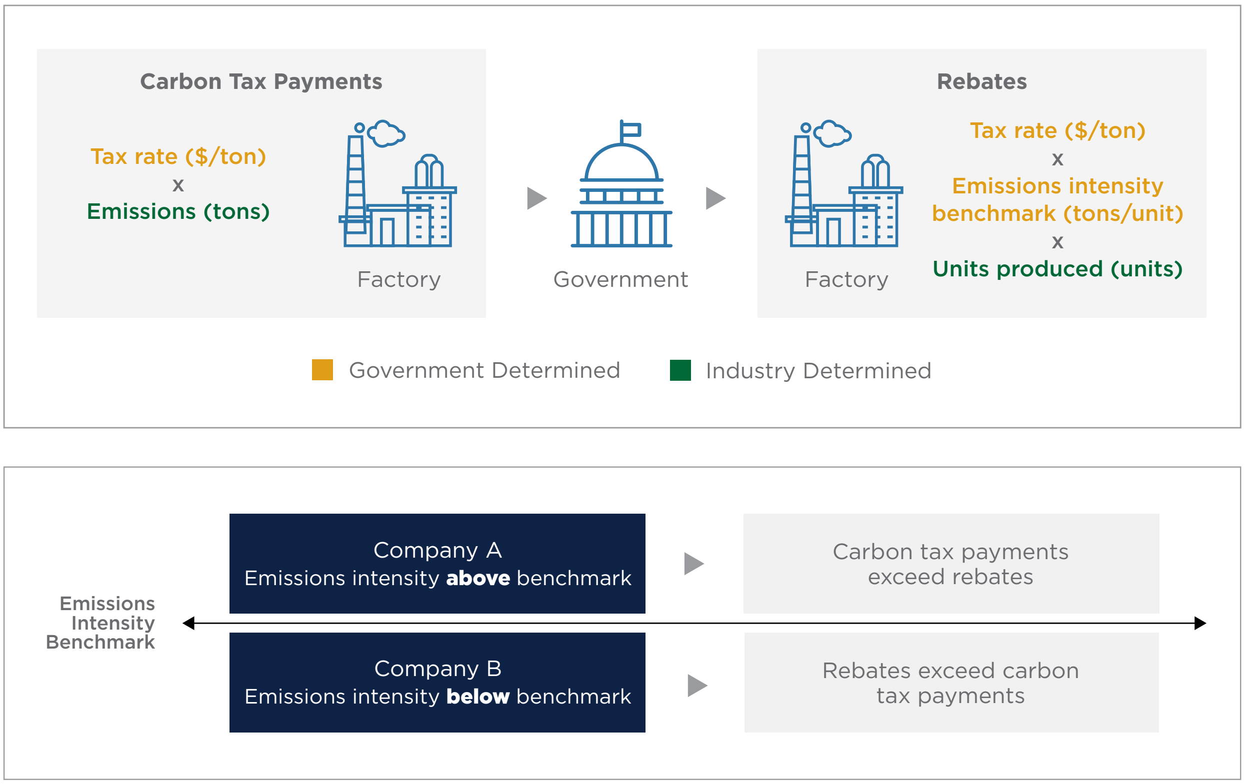
A third challenge relates to regulations in other countries. Some proposals suggest applying the fee equally to all imports, regardless of whether the emissions of foreign competitors are comparably regulated at home.[9] This would cause some products to be taxed or regulated twice for the same emissions unless the home country put in place a reciprocal BCA. Other proposals suggest charging a lower (or zero) fee on imports from countries with climate regulations. However, no countries' climate policies consist of a simple carbon price; they are patchworks of regulations and subsidies that are difficult to objectively convert into a single metric. Additionally, some scholars are concerned such an approach could violate the principles of non-discrimination required by international trade law.[10] However, others assert that accounting for other countries' regulations is the best way to comply with the rules of the World Trade Organization.[11]

To be sure, there are plausible solutions to each of these challenges. However, in combination they present significant enough obstacles that policymakers would do well to also consider other approaches. A primary alternative strategy to a BCA is an output-based rebate (OBR).

## Explaining Output-Based Rebates

Under an output-based rebate, domestic producers of EITE products would receive a payment for every unit of production in addition to paying a tax on the carbon they emit. The size of the rebate payment could be designed to compensate a typical producer for its carbon tax payments using emissions intensity "benchmarks" that reflect the typical emissions rate for domestic producers of that product. For producers that emit at a rate higher than the established benchmark, their carbon tax payments would exceed the rebates they receive; the opposite would be the case for producers that emit at a rate lower than the benchmark. Figure 1 shows how this would work in practice.

**Figure 1:** Output-based rebates example




By offsetting the higher production costs arising from the carbon price, output-based rebates can put domestic firms back on a level playing field with foreign competitors that are not subject to comparable regulations, thus keeping American firms competitive.

Importantly, an OBR compensates domestic firms while retaining the most important incentive of the carbon price: increasing the relative price of more carbon-intensive inputs to production.

Indeed, as part of its carbon pricing policy, Canada has an “Output-Based Pricing System” which gives firms rebates, in the form of tax credits, based on their production. For example, the emissions-rate benchmark for gray cement is 0.733 tons of CO2 emitted for every ton of cement.[12] That means all firms receive a payment equal to 73 percent of the carbon tax for every ton of cement they produce. If a firm emits less than 0.733 tons of $CO_2$ per ton of cement, it would receive tax credits in excess of its carbon tax bill. If, on the other hand, the firm’s emissions rate is higher than the 0.733 benchmark, its carbon tax payments would exceed the value of its tax credits.[13]

A carbon price also reduces emissions by raising the relative costs of carbon-intensive products to consumers, causing them to consume less; however, output-based rebates could wind up enabling producers to avoid raising prices, thus dampening this channel for emissions reductions. And if the OBR (or BCA for that matter) props up polluting domestic companies, communities adjacent to the facilities—often populated by people of color or with low incomes—could be negatively affected by the government intervention. In designing OBRs (discussed below), policymakers must balance many priorities, including retaining appropriate incentives to reduce emissions, keeping domestic producers on a level playing field with foreign competitors, and minimizing the costs of the rebates.

The major differences between OBRs and BCAs are outlined in Table 1.

**Table 1:** General comparison of policies addressing emissions leakage

| | No mechanism | Output-based rebates | Border carbon adjustments |
|---|---|---|---|
| **Covered entities** | None. | Select energy-intensive and trade-exposed firms. | Select energy-intensive and trade-exposed firms. |
| **Reduces emissions leakage?** | No. | Yes. Compensation puts domestic firms on a level playing field with foreign competitors. | Yes. A fee on imports and a rebate on exports puts domestic firms on a level playing field with foreign competitors. |
| **Implementation hurdles** | None. | Small, due to the administration of the program. | Medium/large, due to the need to assign a carbon context to covered imports and (potentially) a different approach for each country. |
| **Carbon reduction incentive for covered entities** | Full incentive for domestic firms, but foreign emissions may rise due to leakage. | Partial. Producers retain the incentive to reduce emissions, but consumers may not. | Producers and consumers retain the full incentive to reduce emissions. |
| **Risk of international trade issues** | None. | Small. Foreign countries might object or retaliate to rebates if they are seen to improperly benefit US firms. | Medium. A fee on imports increases the risk that foreign countries might object or implement retaliatory tariffs. |
| **Unintended consequences of partial coverage** | None. | Small. Due to the reduced administrative burden, more industries could be covered compared to a BCA, thus avoiding some unintended consequences of partial coverage. | Medium. Failing to cover certain non-EITE products could lead to offshoring of these industries. |
| **Costs** | None. | Would require use of government revenue. | Depends on the balance of carbon embodied in trade. Taxes raised from emissions on imported goods will raise revenue, while rebates for taxes imposed on exported goods will require revenue. |

The practical challenges of implementing an OBR may be substantially lower than implementing a BCA. After all, OBRs avoid the complexities of determining the carbon content of foreign goods and accounting for foreign climate regulations, and they may enable covering a broader set of industries.

However, OBRs are not without their own challenges. The design of output-based rebates involves numerous important decisions:

- *Determining which industries are eligible for payments.* Similar to BCAs, OBRs are likely to target EITE industries that face the largest risks from a unilateral carbon tax. Addressing that challenge requires developing metrics to assess this vulnerability, such as energy- (or carbon-) intensity of production and trade exposure, and thresholds of eligibility for each metric.
- *How to determine benchmarks.* With product-specific payments, policymakers need to decide how to group US products. A smaller number of broadly defined groups would ease administrative burdens, while a larger number of more narrowly defined groups would facilitate accurately compensating firms for their carbon pricing payments. For example, there are multiple ways to make steel, which have very different greenhouse gas (GHG) profiles; policymakers would need to decide whether different methods of producing steel would be subject to different benchmarks.
- *The level of the subsidy.* Eligible firms receive payments based on firm-specific production and product-specific emissions rates. The emissions rate could be tied to the average emissions rate in each industry, so the industry as a whole is compensated for its carbon price payments, or it could be tied to a high-performing firm (say the 90th percentile of emissions rates). Alternatively, the payments could be based on historical emissions rates and production, or they could be updated on an ongoing basis.
- *How to pay eligible firms.* Payment of the rebates could be separate from other government obligations or tied to existing obligations, such as corporate income taxes.
- *The lifetime of the program.* The output-based rebate program could be a permanent feature of the carbon pricing legislation, or it could phase out over time. An OBR could even eventually be supplanted by a BCA if policymakers determine a BCA is the better approach but cannot be implemented right away.

Including output-based rebates in carbon pricing legislation is not a new idea. Economists have long pointed to OBRs as an alternative to BCAs.[14] Output-based rebates resemble free allocations of emissions allowances, a common practice in emissions trading programs around the world, including California's cap-and-trade program and the European Union Emissions Trading System (the EU recently announced its intention to add a border carbon adjustment).[15] However, as noted above, none of the 10 carbon tax bills proposed in the US Congress in 2019–2020 includes output-based rebates.

## Which Industries Might Be Eligible for Output-Based Rebates?

If the primary goal of OBRs is to maintain competitiveness and avoid emissions leakage in the presence of a domestic carbon price, firms should be eligible only if they are truly energy-intensive and trade-exposed. Not all industries are so exposed to international trade that they cannot pass on the costs of carbon to consumers, and not all industries are so energy-intensive that they would see large increases in production costs due to a carbon price. Of course, in practice, politics may also influence decisions about which firms are eligible for rebates.

Deciding which firms receive OBRs is as much an art as a science. The American Clean Energy and Security Act, commonly called the Waxman-Markey climate bill, was introduced in 2009 and included output-based rebates in an attempt to address concerns about competitiveness and leakage. In doing so, the drafters constructed a framework to identify industries that were highly energy- (or greenhouse gas-) intensive and trade-exposed.[16]

To be considered an EITE under Waxman-Markey, an industry[17] needed to have an energy or greenhouse gas intensity of at least 5 percent and a trade intensity of at least 15 percent, or it needed to have a "very high" energy or greenhouse gas intensity, exceeding 20 percent on one of those metrics. These metrics are defined in Table 2.

**Table 2:** Waxman-Markey metrics for OBR eligibility

| Metric | Formula |
|---|---|
| Energy intensity | $\frac{\text{Electricity cost + Fuel cost}}{\text{Value of shipments}}$ |
| Greenhouse gas intensity | $\frac{\text{Greenhouse gas emissions x Carbon price}}{\text{Value of shipments}}$ |
| Trade intensity | $\frac{\text{Total imports + Total exports}}{\text{Value of shipments + Total imports}}$ |

Assessing whether the chosen industries, metrics, or thresholds from Waxman-Markey are appropriate is outside the scope of this commentary. We borrow the Waxman-Markey framework to develop two scenarios for potential eligibility for output-based rebates: (1) we assume the same industries deemed eligible by the Waxman-Markey bill are eligible today; (2) we use the same metrics and thresholds as the Waxman-Markey bill to determine which industries would be deemed eligible today, more than a decade after the bill was introduced.

In response to a request from a group of senators, the Environmental Protection Agency produced a report analyzing the expected impacts of Waxman-Markey.[18] The 2009 report identified 46 industries as "presumptively eligible" for OBRs (referred to as "output-based allowance allocations" in the bill) based on data assembled from 2006 (for GHGs) and 2007 (for trade and other economic indicators). The highest-emitting industries were iron and steel mills (134 MMT), cement manufacturing (85 MMT), and organic chemical manufacturing (54 MMT). All but one industry, lime manufacturing, met the bill's threshold for trade exposure. (The trade exposure of most eligible industries far exceeded the 15 percent threshold.) Lime was still deemed eligible due to its high GHG intensity of 33 percent. Most of these industries involve the production of commodities traded globally in open, competitive markets and presumably would have had difficulty passing on a substantial cost increase associated with a carbon price.

We compare data from the time period used for Waxman-Markey eligibility to data from 2016–2018 as a proxy for current conditions, and we update EITE status and emissions in 2018 for manufacturing North American Industry Classification System (NAICS) codes using the same factors stipulated in Waxman-Markey bill language.[19]

Starting with trade intensity, the current landscape looks roughly the same as in 2006–2007. There have been two revisions to the NAICS system, resulting in the consolidation of the original 46 industries into 32 distinct industries today. The trade intensity of these industries decreased on average by about 2 percentage points. Nearly all of the 32 industries still have trade intensity of above 20 percent. The exceptions are the cement, petrochemicals, and paper mills industries, which fell below the trade-intensity threshold proposed in Waxman-Markey, as shown in Table 3.

**Table 3:** Trade intensities in select industries, 2007 and 2018

| Industry | Trade intensity (2007) | Trade intensity (2018) |
|---|---|---|
| **2007 EITE industries (average)** | 40% | 38% |
| **Paper (except newsprint) mills** | 17% | 14% |
| **Cement** | 19% | 12% |
| **Petrochemical** | 17% | 11% |

*Sources: Rhodium Group analysis, US International Trade Commission, US Census Bureau*

The data on energy intensity show a different trend. Nearly half (15) of the 32 industries eligible based on 2006–2007 data are no longer sufficiently energy intensive to qualify under the Waxman-Markey framework, as shown in Table 4.

**Table 4:** Energy intensities in select industries, 2007 and 2018

| Industry | Energy intensity (2007) | Energy intensity (2018) |
|---|---|---|
| 2007 EITE industries (average) | 8% | 5% |
| Malt | 9% | 3% |
| Iron and steel mills and ferroalloy | 9% | 4% |
| Clay building material and refractories | 8% | 4% |
| Synthetic dye and pigment | 6% | 3% |
| All other basic organic chemical | 6% | 3% |
| Artificial and synthetic fibers and filaments | 6% | 4% |
| Petrochemical | 6% | 4% |
| Carbon and graphite product | 6% | 4% |
| Iron foundries | 6% | 4% |
| Pottery, ceramics, and plumbing fixture | 5% | 3% |
| Synthetic rubber | 5% | 3% |
| Cyclic crude, intermediate, and gum and wood chemical | 5% | 3% |
| Rope, cordage, twine, tire cord, and tire fabric mills | 5% | 3% |
| Plastics material and resin | 5% | 4% |
| Fiber, yarn, and thread mills | 5% | 4% |

*Sources: Rhodium Group analysis, US Census Bureau*

While the exact explanations for these changes are industry specific, one overarching trend is that energy costs have declined substantially in the intervening years. Most notably, the price of natural gas for industrial users has declined by 50 percent since 2007. As a result, across the manufacturing sector as a whole, the cost of purchased fuels as a share of the value of shipments also decreased by about half from 2006–2007 to 2018, and by 51 percent in absolute terms (in real 2018 dollars).

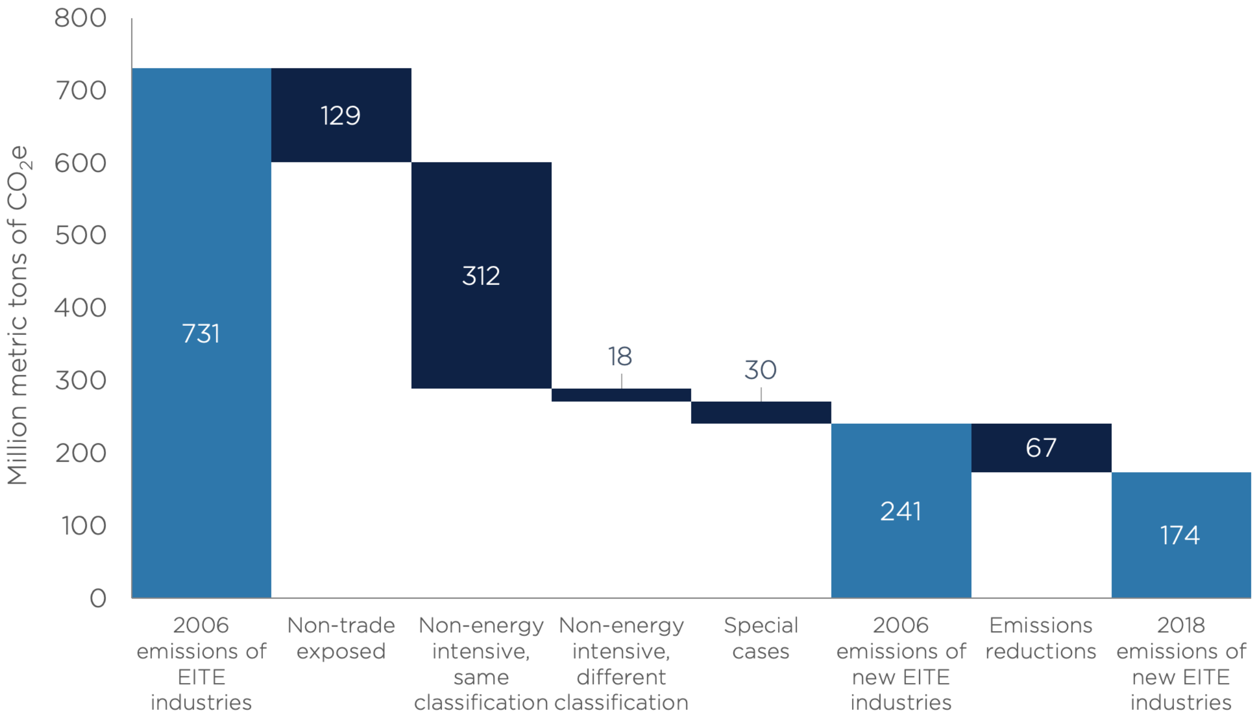
Industries eligible for OBRs under Waxman-Markey emitted 731 million metric tons of $CO_2e$ in 2006, which was about 50 percent of manufacturing emissions. These same industries emitted 496 million metric tons in 2018. The data from 2018 show that if the same metrics and thresholds were used to determine eligibility today:

- 129 million tons (18 percent) of 2006 emissions come from industries that would no longer be eligible due to lower trade exposure
- 312 million tons (43 percent) of 2006 emissions come from industries that would no longer be eligible due to lower energy intensity

- 48 million tons (7 percent) of 2006 emissions come from industries that would no longer be eligible due to NAICS reclassifications (as discussed above) or certain special cases[20]

The remaining 14 eligible industries have also seen annual emissions decline—by 67 million tons—since 2006.[21] That leaves just 174 million tons of GHG emissions from industries eligible for output-based rebates (see Figure 2), which is just 24 percent of the emissions eligible using the 2006 data and 43 percent of total manufacturing emissions.

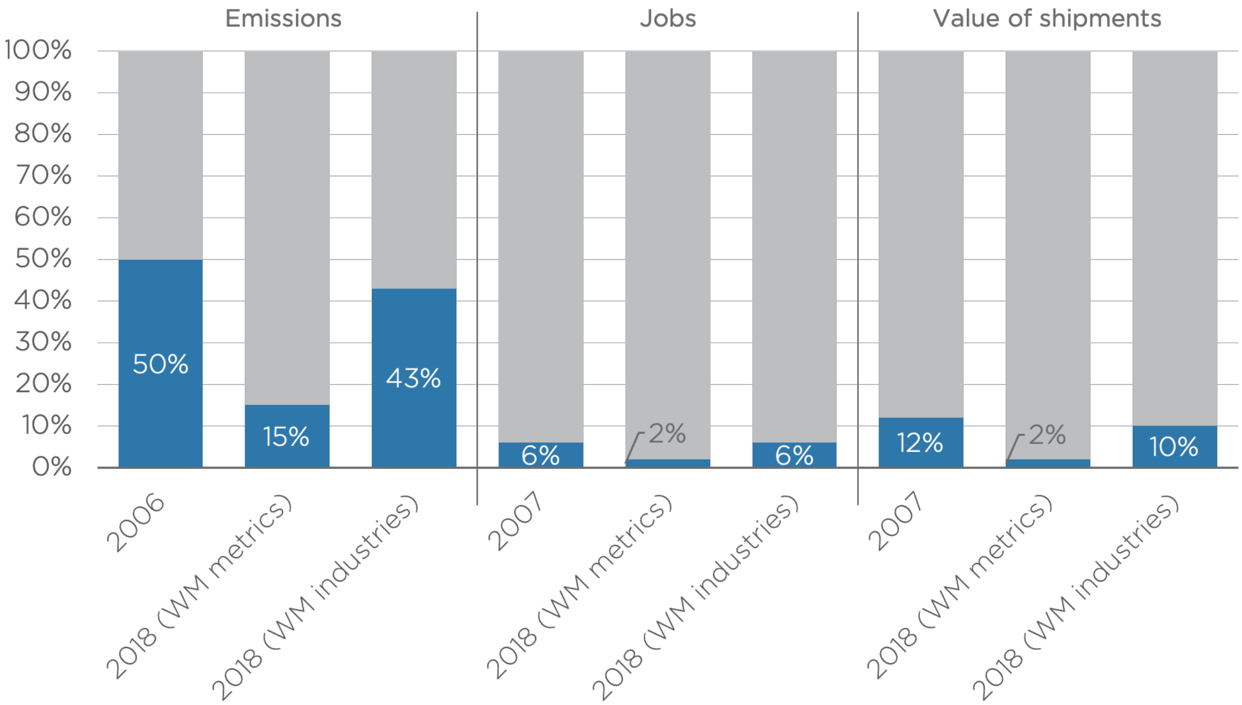
**Figure 2:** Decomposition of emissions coverage, 2006–2018




*Sources: Rhodium Group analysis, US International Trade Commission, US Census Bureau, Environmental Protection Agency*

Finally, Figure 3 shows that when the Waxman-Markey thresholds are used to determine eligibility, the industries that would be eligible today account for a much smaller share of the US manufacturing sector than when using metrics other than emissions, such as jobs and value of shipments. Alternatively, when the Waxman-Markey-eligible *industries* are assumed to retain eligibility for OBRs today, the emissions, jobs, and value of shipments eligible for rebates would still fall, but the drop would not be nearly as large.

**Figure 3:** Percent of manufacturing emissions, jobs, and value of shipments eligible for OBRs, 2006–2007 and 2018




*Sources: Rhodium Group analysis, US International Trade Commission, US Census Bureau, Environmental Protection Agency*

## Estimating the Value of Output-Based Rebates

A key advantage of using a border carbon adjustment to address concerns of competitiveness and leakage caused by a carbon price is that due to the offsetting effects of taxing imports and providing a rebate to exports, a BCA may not require any additional government revenue. In contrast, output-based rebates would need to be funded, for example, with a portion of the revenue from the carbon price. But how much revenue is needed?

The Waxman-Markey cap-and-trade program would have set aside about 13–16 percent of emissions allowances to fund the output-based rebate program.[22] Assuming the OBRs are designed such that they, on average, equal the payments of the carbon tax by eligible industries, that is equivalent to using 13–16 percent of the revenue from a carbon tax for OBRs.

Covering the same industries or using the same metrics and thresholds as Waxman-Markey today would require a smaller share of funding from a carbon tax due to the changes in energy intensity and trade intensity of US manufacturing, among other smaller factors described above. In particular, assuming the same industries covered by Waxman-Markey are eligible for rebates, roughly 10 percent of the carbon tax revenue is required to fund the OBR program. Using the same metrics and thresholds as Waxman-Markey to determine eligibility, between 3 and 4 percent of the carbon tax revenue is needed to fund the OBR program (see Table 5). Assuming a carbon price of $25/ton, that is equivalent to $4.35 billion to $12.4 billion annually.

That would leave 90 to 97 percent of the carbon tax revenue for other priorities, which may include rebates or tax cuts to individuals or investments in clean energy or other government programs. A portion of the remaining revenue could also enable a broader portion of US industries to be covered by OBRs.

**Table 5:** Characteristics of OBRs under Waxman-Markey approaches

| | WM metrics | WM industries |
|---|---|---|
| **Total EITE emissions (MMT)** | 174 | 496 |
| **% of total energy sector $CO_2$** | 3.45% | 9.83% |
| **Total rebate value at $25/ton** | $4.35 billion | $12.4 billion |

*Sources: Authors' calculations*

## Conclusions and Next Steps

A carbon pricing policy can be designed to keep domestic industries on a level playing field with foreign competitors and lessen emissions leakage. All but one of the 11 carbon prices proposed in the US Congress in 2019–2020 include a border carbon adjustment to accomplish these goals.

Indeed, a BCA has some unique advantages: for example, it is unlikely to require government revenue (in fact, a BCA may raise additional revenue), and consumers retain the full incentive to change behavior from the carbon price signal. A BCA may be the best approach for keeping domestic industries on a level playing field with foreign competitors.

But it is not the open-and-shut case that the consensus in current proposals might suggest. Policy makers may wish to consider output-based rebates, which are not included in the recent proposals to Congress, as an alternative to BCAs for the following reasons:

- OBRs avoid the complexities of determining the carbon content of foreign goods;
- OBRs avoid the complexities of accounting for foreign regulations;
- Due to the reduced administrative complexity, a larger portion of industries could receive OBRs than BCAs;
- The revenue requirements are arguably small (perhaps 3 to 10 percent of total carbon tax revenue using the precedents of Waxman-Markey).

Another possibility is that an OBR program could transition into a BCA program in the future, allowing more time to set up a complex administrative structure and/or enable other countries to adopt similar programs.

Importantly, neither a BCA nor an OBR is a panacea. Some emissions leakage will take place due to other factors like relative price changes of internationally traded products.[23] In addition, supporting domestic industries that pollute can have an obvious downside to affected local communities. Depending on policy design, mechanisms to prevent leakage overseas mean that harm to Americans living near polluting facilities will remain, disproportionately affecting people of color and those in lower-income neighborhoods.[24] The impact of the carbon price may be beneficial to disadvantaged communities on the whole (this appears to be the case in California, for example[25]), but local equity is a key issue in designing any climate policies, including OBRs.

The findings in this commentary raise various questions the authors plan to explore, including:

- **Are the Waxman-Markey metrics and thresholds appropriate?** Alternatively, might other metrics or thresholds capture a fuller picture of vulnerable domestic industries?
- **How important is addressing competitiveness and emissions leakage?** For example, is the prevention of international leakage of up to 174 million metric tons of greenhouse gases (about 0.3 percent of global GHGs) and the protection of about 2 percent of the total value of US industrial shipments worth the complexity added by a BCA or OBR program?

## Notes

1. There is another form of emissions leakage that can occur when a major economy imposes an ambitious climate policy (e.g., a carbon price or other measures) that materially reduces global demand for fossil fuels. When this occurs, global prices for fossil fuels decline, all else being equal, allowing firms not subject to the carbon price to take advantage of lower energy costs. This phenomenon has the potential to lead to higher emissions that offset some of the reductions in the country taking climate action. See Liwayway Adkins et al., "The Impact on U.S. Industries of Carbon Prices with Output-Based Rebates over Multiple Time Frames" (working paper, Resources for the Future, Washington, DC, 2010), https://www.rff.org/publications/working-papers/the-impact-on-us-industries-of-carbon-prices-with-output-based-rebates-over-multiple-time-frames-1/, for more discussion. This non-trade related form of leakage is not a focus of this paper.
2. Jason Ye, "Carbon Pricing Proposals in the 116th Congress." Center for Climate and Energy Solutions, September 2020, https://www.c2es.org/document/carbon-pricing-proposals-in-the-116th-congress/.
3. Ibid.
4. Samuel S. Kortum and David A. Weisbach, "Border Adjustments for Carbon Emissions: Basic

Concepts and Design" (working paper, Resources for the Future, Washington, DC, 2016).

5. In 2018, the US exported 9,245 products and 18,607 products were imported (at the HS10 digit level). See https://wits.worldbank.org/countrysnapshot/en/USA/textview.

6. Christian Lininger, *Consumption-Based Approaches in International Climate Policy* (Cham, Switzerland: Springer Climate, 2015.

7. Kortum and Weisbach, "Border Adjustments for Carbon Emissions."

8. Brian Flannery et al., "Framework Proposal for a US Upstream Greenhouse Gas Tax with WTO-Compliant Border Adjustments" (working paper, Resources for the Future, Washington, DC, 2018).

9. Ye, "Carbon Pricing Proposals in the 116th Congress."

10. Ibid.

11. "WTO and the Border Adjustment Laser Talk," Citizens' Climate Lobby, n.d., https://citizensclimatelobby.org/laser-talks/wto-and-the-border-adjustment/.

12. Different types of cement require different amounts of energy to produce. Gray cement, largely used in construction, has a different emissions-rate benchmark than, for example, white cement, which is used for more aesthetic purposes.

13. Output-Based Pricing System Regulations, SOR/2019-266 § (2019), Government of Canada: Justice Laws, https://laws-lois.justice.gc.ca/eng/regulations/SOR-2019-266/FullText.html.

14. Carolyn Fischer and Alan K. Fox, "Comparing Policies to Combat Emissions Leakage: Border Carbon Adjustments Versus Rebates," *Journal of Environmental Economics and Management* 64, no. 2 (2012): 199–216.

15. Francesco Guarascio and Jonas Ekblom, "Explainer: What an EU Carbon Border Tax Might Look like and Who Would Be Hit," Reuters, December 10, 2019, https://reut.rs/3lnsqT6.

16. Waxman-Markey also provided for border adjustment for these industries if products are imported from other countries that have not taken action on climate.

17. Waxman-Markey defined industries by their six-digit NAICS code—for example, "Tire Manufacturing" or "Iron and Steel Mills and Ferroalloy Manufacturing."

18. "The Effects of H.R. 2454 on International Competitiveness and Emission Leakage in Energy-Intensive Trade-Exposed Industries," EPA, December 2, 2009, https://www.epa.gov/sites/production/files/2016-07/documents/interagencyreport_competitiveness-emissionleakage.pdf.

19. For energy and trade intensity, we use the United States Census Annual Survey of Manufacturers (2015–2018), United States International Trade Commission data (2015–2018). For greenhouse gas emissions, the bill stipulates use of "the best available data." We use data from the EPA's Environmentally Extended Input-Output Model, which

provides NAICS code-level GHG emissions for the year 2013, https://www.sciencedirect.com/science/article/abs/pii/S0959652617308806.

20. The EPA analysis included several metal production NAICS codes that they determined presumptively eligible on the basis of Waxman-Markey bill language, not the energy intensity of those specific NAICS codes. We exclude those industries from this analysis.

21. These emissions reductions could be due to a variety of factors including fuel switching, improvements in energy efficiency, and switching to less GHG-intensive processes but also structural changes like reduced output or offshoring of some production.

22. Waxman-Markey took a phased approach to covering emissions. In the first phase, industrial emissions were not covered at all. In the second phase, most industrial emissions were included and 15 percent of allowances, or 757 million tons, were set aside for the OBR program. At the start of the third phase, 13.4 percent of allowances, or 729 million tons, of allowances were set aside. As the emissions cap declined, the share of allowances remained at 13.4 for 10 years and then phased down to zero over several years. For more information, see John Larsen, Alexia Kelly, and Robert Heilmayr, "WRI Summary of H.R. 2454, the American Clean Energy and Security Act (Waxman-Markey)," World Resources Institute, 2009, https://pdf.wri.org/wri_summary_of_aces_0731.pdf.

23. Joseph E. Aldy, "Frameworks for Evaluating Policy Approaches to Address the Competitiveness Concerns of Mitigating Greenhouse Gas Emissions" working paper, Resources for the Future, Washington, DC, 2016; Fischer and Fox, "On the Scope for Output-Based Rebating in Climate Policy."

24. Lara J. Cushing et al., *A Preliminary Environmental Equity Assessment of California's Cap-and-Trade Program* (Los Angeles, USC Program for Environmental and Regional Equity 2016), https://dornsife.usc.edu/PERE/enviro-equity-CA-cap-trade.

25. Danae Hernandez-Cortes and Kyle C. Meng, "Do Environmental Markets Cause Environmental Injustice? Evidence from California's Carbon Market" working paper 27205, National Bureau of Economic Research, Cambridge, MA, 2020, https://www.nber.org/papers/w27205.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