PIIE PETERSON INSTITUTE FOR INTERNATIONAL ECONOMICS

WORKING PAPER

23-3 Carbon border adjustments, climate clubs, and subsidy races when climate policies vary

Kimberly A. Clausing and Catherine Wolfram

May 2023

The PIIE research assistance for this project was funded by financial support from a multiyear grant from the Danish Embassy in Washington for PIIE research related to developing economies and climate change.

ABSTRACT

Jurisdictions adopt heterogeneous climate policies that vary both in terms of ambition and in terms of policy approach, with some jurisdictions pricing carbon and others subsidizing clean production. We distinguish two types of policy spillovers associated with diverse policy approaches to climate change. First, when countries have different levels of climate ambition, free-riders will benefit at the expense of more committed countries. Second, when countries pursue different approaches, carbon-intensive producers within cost-imposing jurisdictions will be at a relative competitive disadvantage compared with producers in subsidizing jurisdictions. Carbon border adjustments and climate clubs are attempts to respond to these policy spillovers, but when countries have divergent policy approaches, one policy alone will not be able to address both types of spillovers. We also consider the policy dynamics that result from carbon border adjustments and climate clubs; both have the potential to encourage upward harmonization of climate policy, but they come with risks. Further, the pressures of international competition in the presence of divergent climate policy approaches may result in subsidy races, which come with their own potential risks and benefits.

JEL Codes: F18; H23; Q54; Q58

Keywords: carbon border adjustments; climate clubs; Pigovian taxes and subsidies; international competitiveness; trade and environment

Kimberly Clausing, nonresident senior fellow at the Peterson Institute for International Economics, is the Eric M. Zolt Chair in Tax Law and Policy at UCLA School of Law.

Catherine Wolfram is the Cora Jane Flood Professor of Business Administration, University of California, Berkeley, Haas School of Business. When this paper was written, she was Visiting Raymond Plank Professor at Harvard Kennedy School. Clausing and Wolfram are also research associates at the National Bureau of Economic Research.

Authors' Note: This paper is forthcoming in the *Journal of Economic Perspectives*. We received helpful feedback from Joseph Aldy, Laura Alfaro, Chad Bown, Meredith Fowlie, Steven Fries, Luis Garicano, Cullen Hendrix, Arik Levinson, Thornton Matheson, Jean Pisani-Ferry, William Pizer, Jacquelyn Pless, André Sapir, Joseph Shapiro, Robert Stavins, Matthew Tarduno, Jeromin Zettelmeyer, and participants at the Harvard Kennedy School of Government's conference on the Political Economy of Climate Change Policy, the Peterson Institute for International Economics seminar, the Salata Institute for Climate and Sustainability at Harvard University conference on "Can Trade Policy Work for the Climate?", the National Tax Association Spring Symposium, and the World Resources Institute seminar. We received helpful research assistance from Andrew Chu, Julieta Contreras, James Murray, and Matthew Tarduno. We are grateful for helpful editorial suggestions and feedback from Erik Hurst, Nina Pavcnik, Timothy Taylor, and Heidi Williams.

Climate change is a global problem: carbon emitted anywhere contributes to atmospheric carbon levels everywhere, and policies that reduce carbon emissions benefit the entire world. However, climate change policy is usually adopted at the national (or subnational) level, and in a globally integrated economy, international trade can create important policy spillovers. For example, whenever a jurisdiction puts a price on carbon, it faces two concerns. First, its producers may face a competitive disadvantage, since other jurisdictions may not price carbon and might even subsidize energy. Second, the benefits of ambitious climate policy will be limited since the country will reap only a share of the gains: that is, any emissions reductions will benefit all jurisdictions, regardless of their policy stance. Both concerns may lead governments to adopt insufficiently ambitious climate policies.

As a starting point, a conceptual framework for climate change mitigation policies might usefully be thought of as occupying a two-by-two matrix, with policy ambition on one axis, and approach (taxes versus subsidies) on the other.[1] For example, Canada (with a carbon price of about $50 per ton in 2023 that is scheduled to rise) might be designated as primarily using a high ambition, tax-based approach, whereas Colombia (with a carbon price of $5 per ton) might be classified as emphasizing a low ambition tax-based approach. The United States could arguably be classified as emphasizing a low ambition cost-reducing approach up through 2021, but after passing the Inflation Reduction Act in 2022, it is arguably on track to use a high ambition, subsidy-based approach. (Regulations can also be considered as an implicit tax, but the quantitative impact of such an implicit tax may be small and/or difficult to measure.)

Table 1: Matrix of Jurisdictions by Climate Mitigation Ambition and Approach

	High Ambition	Low Ambition
Cost Imposing	Country A	Country B
Cost Reducing	Country C	Country D

[1] While we use the term "ambition", which sometimes has a normative connotation, to differentiate levels of climate policy, it is important to recognize that rich countries have contributed a much larger share of the current stock of greenhouse gas emissions.

In this essay, we begin by documenting the variation in climate change policies across countries focusing on the rows of Table 1: that is, we describe policies that impose a cost on carbon and then policies that seek to reduce the cost of shifting to less carbon-intensive processes. We discuss concerns raised by these policies, including effects on competition between nations that have adopted divergent approaches. For instance, cost-imposing jurisdictions may be concerned that their companies face a disadvantage when competing with companies based in jurisdictions that subsidize the transition to a low-carbon economy, particularly in industries that are both traded in a global market and carbon intensive, such as chemicals. These concerns can even lead to “subsidy races”, a dynamic we discuss below.

In addition, consider variation in climate change policies focusing on the columns of Table 1. Countries undertaking ambitious policy action (either cost-imposing or cost-reducing) may be concerned that other countries will forgo strong climate policy measures, instead free-riding on others’ costly efforts. Countries that subsidize face fiscal costs, and cost-imposing countries that regulate or tax also face political economy costs from implementing cost-imposing policies. The political economy of bearing these costs may be impacted by the number of other countries taking similar measures.

We then turn to two main proposals to address these policy spillovers. First, “carbon border adjustment mechanisms” seek to address competitiveness concerns by imposing costs on imports to reflect differences in climate policies across countries. Second, “climate clubs” (as proposed by Nordhaus (2015)) would have ambitious climate-policy “club” countries levy a broad tariff on less ambitious “non-club” countries in order to inspire greater mitigation action. We describe the economic policy issues raised by each remedy, drawing on recent literature. By responding to the competitiveness concerns of domestic industry, as well as the fear that other countries will free ride on domestic efforts, enforcement mechanisms such as carbon border measures or climate clubs have the potential to enable more effective policies globally, but there are also important policy risks.

Throughout our discussion, we emphasize that beyond the static, immediate effects of these policies, the ways in which they drive the evolution of future policy may be even more important. Under what conditions would carbon border adjustments and climate clubs lead to a “race to the top” and encourage a globally harmonized approach to climate mitigation? Or, might carbon border measures or climate clubs simply ignite trade disputes, eroding the gains from trade and undermining climate policy? In the absence of border measures, will the pressures of international competition and domestic politics in the presence of asymmetric approaches to carbon mitigation unravel even the best-intentioned, most ambitious governments’ climate strategies? Are there alternative ways to foster improved alignment of ambitious climate policy?

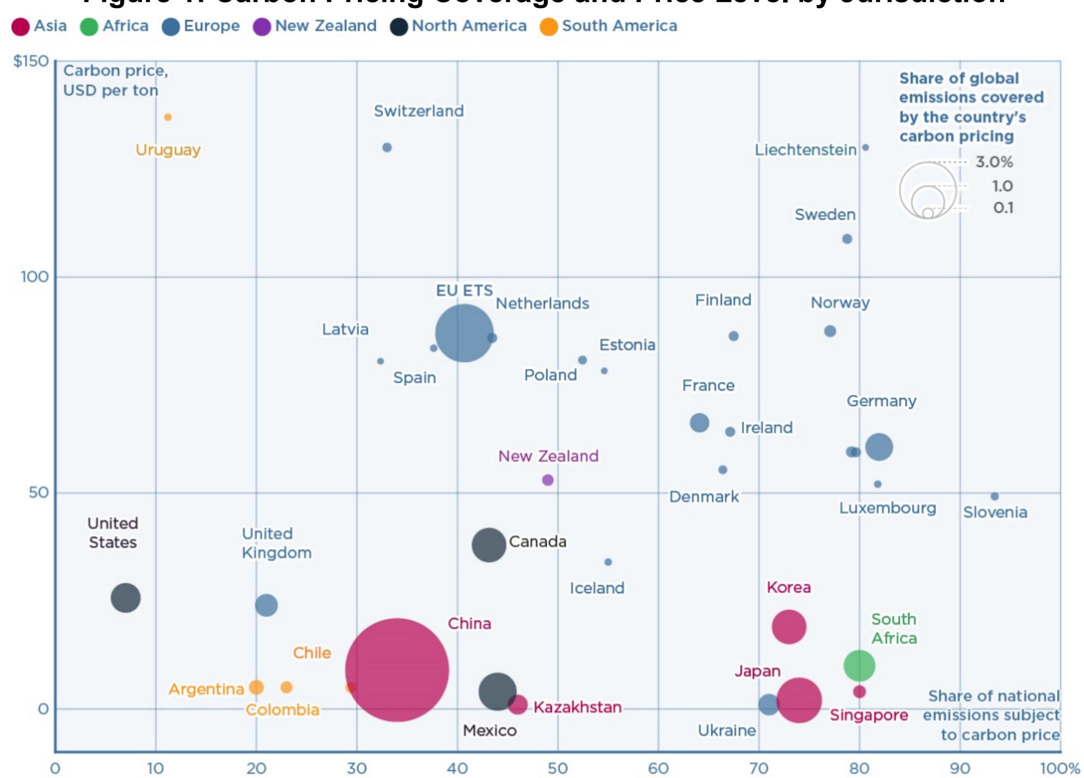
Carbon Pricing to Reduce Carbon Emissions

Carbon pricing efforts take multiple forms. Some jurisdictions price carbon directly and impose a carbon tax. Others price carbon by limiting emissions, and then allowing trading of emissions permits in a “cap-and-trade” system; companies with excess emissions allowances may sell permits (and thus face an opportunity cost for emitting carbon), while those with deficit emissions allowances may buy them (and thus face a direct monetary cost for emitting carbon).

Cross-National Variation in Carbon Prices

Figure 1 shows the current state of carbon pricing efforts throughout the world, as compiled by the World Bank Carbon Pricing Dashboard and the European Environment Agency, with adjustments by the authors to allocate the impacts of the supranational climate policies in the European Union to member countries. The horizontal axis shows the share of carbon emissions (or carbon-equivalent of other emitted greenhouse gases) in the country covered by carbon pricing. The vertical axis shows the price of carbon. The size of the circles is scaled to the share of global carbon emissions from that country. The colors of the circles refer to the continent where the emissions occurred. In countries with sub-national policies or sector-specific policies, the graph reflects the weighted average carbon price. In the United States, for example, the weighted average price across jurisdictions with carbon pricing was about $25 per ton.

Figure 1: Carbon Pricing Coverage and Price Level by Jurisdiction



Source: World Bank Carbon Pricing Dashboard: https://carbonpricingdashboard.worldbank.org/, European Environment Agency: https://www.eea.europa.eu/data-and-maps/data/data-viewers/greenhouse-gases-viewer, and authors' calculations. Emissions refer to greenhouse gas emissions. Carbon price is per ton of CO^2-equivalent. Emissions covered by the EU Emissions Trading System are allocated to participating countries assuming an equal share of power and industrial emissions (69%) are covered in each country. We also represent the EU ETS as a whole. Note that these data do not reflect fossil fuel subsidies or taxes such as gasoline taxes.

As of 2022, the World Bank Carbon Pricing Dashboard indicates that 70 jurisdictions – including 47 national jurisdictions as well as subnational jurisdictions – were subject to some form of explicit carbon pricing, covering 23 percent of all global greenhouse gas emissions. The policies in these jurisdictions don't just vary in terms of design; there is also substantial variation in the implied price of emissions. In April 2022, prices were over $80 per ton in the European Union, and even higher in some national European jurisdictions and Uruguay. Canada's price was $40 per ton in 2022, but it is scheduled to increase by $15 Canadian (about $11 in U.S. dollars) per year between 2023 and 2030. California has the highest carbon price in the United States, at over $30 per ton in April 2022. Many subnational jurisdictions have modest carbon prices, including those in Japan and China, where carbon prices were under $15 per ton in mid-2022.

The share of emissions covered also varies. While 23 percent of greenhouse gas emissions worldwide are covered by some sort of pricing regime, that share is over 80 percent in Germany, 74 percent in Japan, 34 percent in China, and 78 percent in British Columbia. Within the nations belonging to the OECD, one-third of greenhouse gas emissions are covered by an explicit price, and the share rises to nearly 55 percent when the United States is excluded.[2] Multiplying the share of emissions covered by the carbon price times the price itself provides a sense of the economy-wide average carbon price, which varies from near-zero in many countries to over $50 per metric ton in Norway and Sweden and over $100 per metric ton in tiny Liechtenstein.

International organizations have been enthusiastic about carbon pricing efforts: for the IMF, see Parry et al. (2021), Parry (2021), and Jessop et al. (2022); for the World Bank, see World Bank (2014); and for the OECD, see OECD (2021) and IMF/OECD (2021). Relatedly, Article 6 of the Paris Agreement seeks to leverage trading to find low-cost approaches to mitigating emissions around the world. Article 6 governs the trading of carbon credits, allowing an entity in one country to pay for emissions reductions in another country. In this case, however, the emissions reductions may be undertaken voluntarily and may not reflect an explicit policy to price emissions; see World Bank (2022) and Edmonds et al. (2021).

Competitiveness Concerns with Carbon Pricing

There are several domestic impediments to the adoption of emissions policies that impose costs. For example, one concern is the costs to households, particularly those lower in the income distribution. However, such concerns can be offset through other changes in the tax system, including by using carbon fee revenues to compensate lower-income taxpayers. These issues have been addressed elsewhere in the literature (e.g., Goulder et al. 2019 and Horowitz et al. 2017).

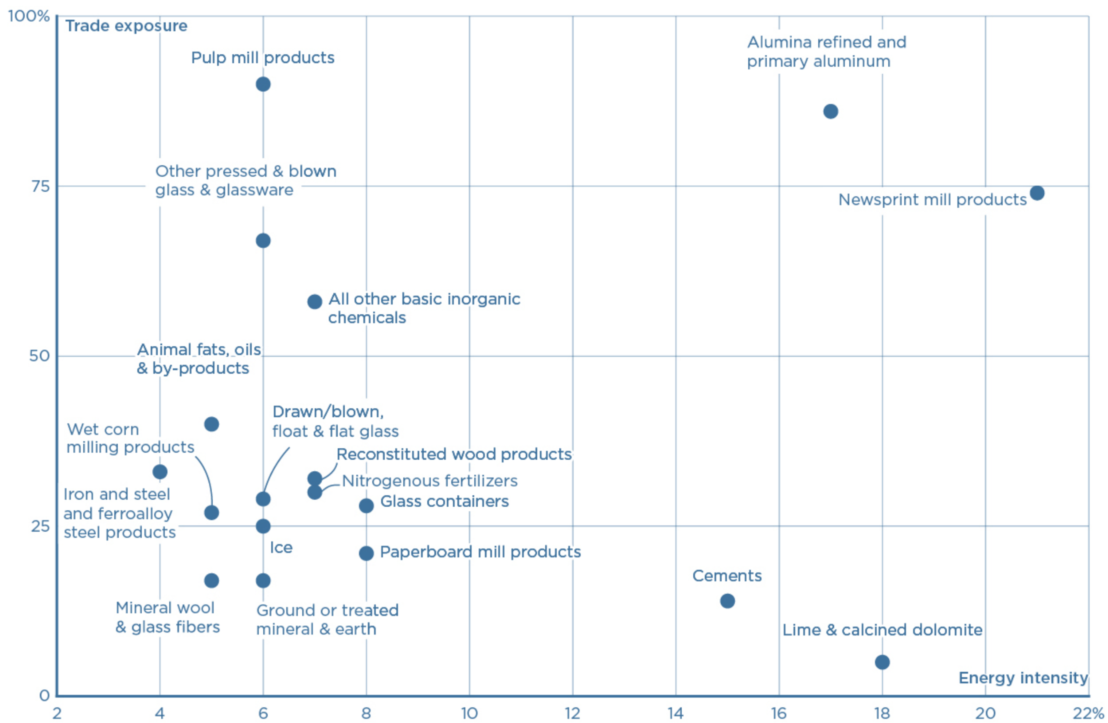
In this piece, we focus on domestic industry concerns that a carbon-pricing policy would injure their competitiveness. Consider a hypothetical jurisdiction that implements a carbon price of $110 per metric ton with no other policy response; its producers would compete with producers

[2] Authors' calculations based on data from OECD (2022).

from other countries that may face no carbon price or that might even have their energy use subsidized. This would generate a competitive disadvantage in the hypothetical jurisdiction's local market, where imports may have cost advantages, and in markets abroad, where competitors may have lower costs of production.

The industries most exposed to competitiveness effects would be those with high energy-intensity and high exposure to trade. Figure 2 shows these industries, using data from the United States in 2019. Energy intensity on the horizontal axis is measured by industry fuel and electricity consumption scaled by industry level shipments. Trade exposure on the vertical axis is measured by total trade (exports plus imports) relative to total domestic shipments plus imports. These data indicate that the industries most affected by such competitiveness concerns would be iron and steel, aluminum, newsprint, glass, and chemicals.[3]

Figure 2: Energy Intensive & Trade Exposed Industries in the U.S.



Source: Authors' calculations based on U.S. Census Bureau data.

To date, the most common policy approach to address competitiveness concerns has been to compensate industry for a large portion of their emissions, so that they only face the carbon price for marginal emissions. For example, in a cap and trade system, firms sometimes receive free permits that allow them to produce at prior production levels without facing an economic loss, but the ability to trade permits means that producers still face marginal incentives to reduce emissions that are analogous to a carbon price; every additional unit they emit costs them either the cost of a permit (if they need to buy one to reach their ideal production levels) or

[3] We do not account for non-energy carbon emissions, which are present in the steel and cement industries.

the opportunity cost of not selling permits at the going price (if they do not need to purchase permits at target production levels). These free permit allocations can then be reduced over time, through reductions in the total number of permits or other phase-outs. For example, California allocated free carbon permits to industry based on a formula that includes a facility's annual production and a benchmark emissions rate, as well as an adjustment factor that declines over time.

However, free grandfathering of allocations for carbon permits only imperfectly restores competitiveness to industries in jurisdictions that price carbon emissions. For instance, the free allocations cover an industry's direct carbon emissions but do not address the fact that energy inputs may be more expensive. Also, the number of free allocations may decline over time, imposing more costs on firms.

In these situations, multinational companies may find it advantageous to relocate carbon-intensive production to other countries. In addition, consumers may find it advantageous to purchase carbon-intensive imports offered at a lower price due to the absence of a carbon price. When behavioral responses like this reduce the amount of policy-induced global greenhouse gas emissions reduction, the effects are referred to as "carbon leakage."

The existing empirical estimates and model-based studies suggest that emissions leakage is limited in practice (Grubb et al., 2022), and a related literature has found inconsistent empirical evidence that firms move to "pollution havens" with low levels of environmental regulation (for example, Aldy and Pizer 2015, Singhania and Saini 2021, Levinson, 2023). Nonetheless, industries (such as those in Figure 2) that are both trade-intensive and energy-intensive are likely to face substantial concerns about this competitiveness channel.

In considering concerns about carbon pricing, it is important to recognize that more than 70 percent of greenhouse gas emissions are domestic, and issues of trade and competitiveness are far less important for addressing those sources of emissions. Of course, drawing a clean line between traded and nontraded sectors can be difficult. Goods that are not traded are often still influenced on the margin by conditions in international markets.

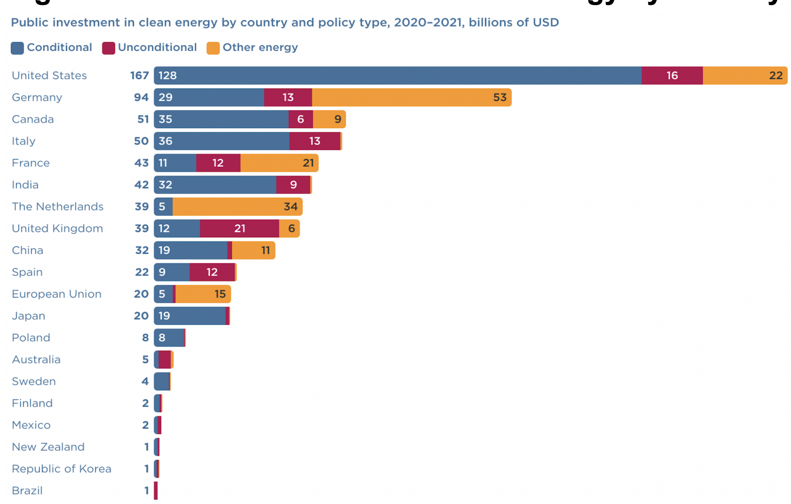
Subsidies for Investment and Innovation to Reduce Carbon Emissions

Some jurisdictions are reluctant to impose costs of carbon reduction directly on firms and consumers. This fear can lead to either inaction, or to imposition of costs in other forms. As a prominent example, the United States (at the federal level) enacted a burst of spending on clean energy and innovation in 2021 and 2022, including spending for clean energy infrastructure and investments as well as a long list of clean energy tax credits.

The most major piece of climate legislation was the 2022 Inflation Reduction Act (IRA). Estimates from the Joint Committee on Taxation and the Congressional Budget Office (2022) pegged the spending on clean energy tax credits and subsidies in legislation at more than $350 billion over ten years, although outside estimates suggest the fiscal costs could be substantially higher if the take-up of tax credits is higher than projected by the government (Bistline, Mehrotra, and Wolfram 2023; Credit Suisse 2022; Penn-Wharton Budget Model 2023). The Infrastructure Investment and Jobs Act of 2021 contains additional clean energy infrastructure investments, including for electric vehicle charging and electricity transmission. Several studies have forecast the likely effectiveness of these subsidies in reducing carbon emissions. As summarized in Bistline et al. (2022), the studies find that the Inflation Reduction Act will likely reduce U.S. carbon emissions by 32-42 percent below 2005 levels in 2030, an improvement relative to a baseline reduction of 6 to 11 percentage points without the legislation.

Figure 3 shows those countries with more than $1 billion in spending for clean energy over the period 2020-2021.[4] While this gives some sense of the extent of recent subsidies, note that these figures are not scaled by country GDP, and some smaller economies spend more as a share of their economy than does the United States or other countries in this figure. The blue "conditional" bars show policies that likely support the transition away from fossil fuels, but do not specifically require environmental safeguards, such as support for public transportation or electric vehicles. The red "unconditional" bars show policies that directly support production or consumption of low-carbon energy. The yellow "other energy" bars show other policies, including (but not limited to) those that support nuclear energy, biofuels, biomass, incineration, and hydrogen.

Figure 3: Public Investment in Clean Energy by Country



Source: The Energy Policy Tracker and authors' calculations.

[4] These data are from a group of nonprofit organizations that track public funding for energy. See: https://www.energypolicytracker.org/about/. The "other" category has been adjusted by the authors to focus solely on projects that reflect spending on clean energy. The data only reflect subsidies committed in 2020-21; they do not capture ongoing programs, such as U.S. subsidies under the Energy Policy Act of 2005, the precursor to the Inflation Reduction Act. They may count planned future spending in a single year. More generally, these data may not reflect longer term trends in spending on clean energy and tax subsidies. However, consistent cross-country data on these measures are not available for a longer time series, although there are initiatives to collect such data in the future.

As with carbon pricing initiatives, subsidy policies vary both across and within jurisdictions. Some policies focus on nascent technologies; others subsidize the use of long-established technologies that might otherwise be phased out (like the tax credit in the Inflation Reduction Act of 2022 for existing nuclear production). Some policies spend directly on infrastructure like charging stations for electric vehicles, whereas other policies provide tax credits or grants for private actors based on their investment, production, or consumption. These policies all have one feature in common: they reduce the costs of investment and/or innovation for private market participants.

While subsidies are often chosen in part due to concerns about imposing costs on consumers or producers, it is important to remember that they have important distributional consequences of their own. For instance, the IRA tax credits will likely disproportionately benefit taxpayers that have higher incomes (see Furman 2023). While subsidies avoid the prospect of directly harming those lower in the income distribution, they also have real fiscal consequences (e.g., less revenue for alternative spending or tax cuts) that may be consequential for these taxpayers.

Finally, note that many jurisdictions pursue more than one type of policy. Some governments rely on both cost-imposing policies (such as taxes, fees, and regulation) as well as cost-reducing policies intended to spur clean energy production.[5] An energy-intensive firm in such jurisdictions may find their fossil-fuel based energy costs rising even as renewable-sourced energy costs are falling.

Competitiveness Concerns and Subsidy Races

Subsidizing investments in carbon-free sources of energy can be economically efficient if free markets underprovide them. This is likely the case in the absence of a coordinated global response to the negative emissions externality, since emissions will still exceed their optimal level, and further reductions in emissions will generate social benefits that exceed the private benefits. From this starting point, there are enormous gains to the entire world from technological improvements that enable less expensive clean energy production, carbon capture and sequestration, and new technological innovations; see Jaffe, Newell, and Stavins (2005). In addition, innovation in carbon mitigation technologies face the same market failures as any innovation: gains are unlikely to be fully captured by the private actors that undertake the relevant investments. This may be particularly true in nascent industries, where learning and technological advancement will lead to industry-wide cost reductions, generating external benefits that do not accrue to early producers. However, instead of strict protection of intellectual property, which is a typical policy lever to incentivize innovation in other contexts, it is important for governments to encourage knowledge transfer and diffusion of technologies that will help reduce carbon emissions. As one example, Athey et al. (2021) argue for mechanisms like advance market commitments for carbon removal technologies.

---

[5] For example, many European countries subsidize the purchase of electric vehicles, support clean-tech manufacturing, and subsidize clean energy production. For more detail, see Kleimann et al. (2023).

However, subsidies to reduce the costs of carbon-free energy have downsides. First, there are budgetary costs, which may be sustainable only in certain fiscal environments. Consider the United States, a useful case given the extent of the subsidies included in the IRA, as well as the international reactions to them. The U.S. Congress passed the Inflation Reduction Act and the Infrastructure Investment and Jobs Act in a relatively permissive fiscal environment, following years of low inflation and low interest rates. As interest burdens on the federal debt increase, alongside high ongoing deficits, fiscal constraints may become more binding.

Second, there are possible negative impacts on other countries. For example, while subsidies to development of carbon-reducing energy sources in the United States can benefit other countries in important ways—including by improving technological progress in clean energy production and by reducing U.S. greenhouse gas emissions—they also raise concerns. In the short run, U.S. subsidies may attract investment, scarce expertise, and critical inputs for the energy transition away from other markets. In addition, U.S. industries will be advantaged relative to those abroad if their energy costs are lower. While officials in the U.S. government have urged other countries to also subsidize their energy transitions, many other countries may not be able to afford a subsidy-based approach, particularly low- and middle-income countries. Moreover, the marginal cost of public funds may be higher in many lower-income countries than in typical high-income countries, due to inefficiencies in tax collection (Besley and Persson, 2014).

Further, foreign concerns about possible negative effects from U.S. subsidies were magnified by the explicit inclusion of “domestic content” preferences in the U.S. legislation: that is, multiple tax credits, including those for wind, solar, and electric vehicles, provided more favorable terms for products that were either made in the United States or, in the case of electric vehicles, in a country with whom the United States had a free trade agreement. While the latter inclusion may have mollified Canadian opposition to these provisions, other trading partners remained deeply concerned about losing production activities to subsidized locations. As one example, Tesla announced that it would move a battery manufacturing facility from Germany to the United States soon after the Inflation Reduction Act passed.

As a consequence of these concerns, the European Union, Japan, Korea, and the United Kingdom all made vociferous complaints about the domestic content provisions of the U.S. clean energy subsidies (for news coverage, see Go 2022; Stangarone 2022; Parker, Bounds, and Williams 2022). In December 2022, France and Germany put forward a statement arguing that the U.S. Inflation Reduction Act implies that Europe needs to adopt a more aggressive industrial policy (Le Maire and Habeck 2022). These issues were also raised at the highest levels, including during White House visits by French President Emmanuel Macron (in December 2022) and European Commission President Ursula von der Leyen (in March 2023). Countries have also begun to negotiate limited trade agreements to attain access to some of the credits, the first of which was between the United States and Japan in March 2023.

U.S. policy stances have also raised concerns about broader effects on the international trading system. Global trade agreements have often focused on reducing domestic content rules and government subsidies to industry. These shifts in U.S. policy worry governments that are in favor of a rules-based trading system, as U.S. policy actions may foreshadow less restraint on these policy tools in broader arenas.

A third concern, related to the controversies over industrial policy, is that U.S. subsidies for clean-energy industries could lead to a subsidy race. The terminology of a "race" refers to the idea of an arm's race, when both sides would save resources by agreeing not to engage in such a race; it is one example of a prisoner's dilemma whereby global collective action can achieve better outcomes than individual jurisdictions operating non-cooperatively. For example, (in the short term), competition for scarce inputs or expertise may raise energy transition costs in other countries. In addition, subsidy races are expensive, putting substantial fiscal strains on countries that enter the race and often excluding lower income countries from the competition.

However, in this case, due to the positive externalities in clean energy sectors, it is not clear that a subsidy race in this specific area is always inefficient. Although there are elements of zero-sum competition, one country's subsidies for clean energy also have the potential to lower worldwide costs of clean energy adoption through industry-wide scale effects, and by leading to important technological innovation. As one example, Chinese subsidies to solar industry production served an important role in lowering the costs of solar energy, leading to greater solar adoption worldwide (Nemet, 2019).

A final concern is that the emphasis on subsidies may affect support for price-based emissions policies, risking decreased support for carbon pricing or for removal of existing fossil fuel subsidies.[6] Countries that impose carbon prices may feel the need to join a subsidy race rather than imposing costs on their producers. In addition, the passage of the U.S. subsidy-based climate policy has been taken by some as an argument that carbon pricing is not necessary or desirable in the U.S. context (Kaufman, 2023).

Carbon Border Adjustment Mechanisms

A "carbon border adjustment mechanism" describes a policy where a jurisdiction with carbon pricing applies import fees based on the carbon content of imported goods; the amount of the border adjustment fee is based on the local carbon price, with an adjustment for any carbon price in the exporting country. For example, if the home market has a $110 per ton carbon price and the foreign market has a $10 per ton carbon price, the tariff would be $100 per ton of carbon embedded in the product. If one unit of the product contained the equivalent of 0.02 tons of carbon, that would imply a $2 fee per unit.

Many competitiveness issues raised by a carbon-pricing policy in the domestic market are addressed by the carbon border adjustment mechanism. In countries with a carbon border

[6] The size of U.S. fossil fuel subsidies is significant. Tax measures alone generate a fiscal cost of more than $31 billion over ten years (U.S. Department of the Treasury (2023, p. 213).

adjustment mechanism, all consumption goods face the same costs associated with their carbon emissions.[7]

In December 2022, the European Parliament and the Council of the European Union reached a provisional agreement to implement a carbon border adjustment mechanism beginning in late 2023; this agreement was finalized in April 2023. The proposed mechanism would levy a fee on imported goods in key energy-intensive, trade-exposed industries; the fee would be set at a level that would offset the competitive disadvantage associated with European Union carbon costs.[8] The proposal was designed to level the playing field in a manner that was consistent with World Trade Organization rules. For example, the EU carbon border adjustment mechanism would be phased in as free allowances for carbon-based output are phased out, causing both domestic and foreign producers to be treated similarly. Canada and the United Kingdom are also considering implementing carbon border adjustment mechanisms.

While a carbon border adjustment can address competitiveness issues in the local market, there are also important questions about competitiveness in external markets. One approach would be to refund the domestic carbon prices for exports. While this kind of export rebate can address competitiveness in third markets, it is likely to prove contentious. Rebating carbon fees for exports runs the risk of dampening emissions reduction efforts at home. It may also raise political concerns to treat carbon produced for export goods differently from carbon involved in domestic production.

Measurement and Mitigation Incentives

Implementing a carbon border adjustment mechanism poses practical challenges. One central question is measurement. A carbon border adjustment mechanism is based on the carbon-content of individual imported goods, adjusting for the cost difference between domestic and foreign carbon costs.

As one might expect, informational imperfections make it difficult to assess the carbon-intensity of individual shipments. If customs officials instead rely on more aggregated measures, like industry- or country-level emissions ratios, it can affect incentives in unexpected or even counterproductive ways. For example, imagine the European Union levied a fee based on the carbon-intensity of foreign aluminum imports measured at the plant level. Exporters facing

---

[7] The argument for a carbon border adjustment mechanism is different from arguments that would equalize other policy or economic differences among countries, by (e.g.) levying tariffs when foreign minimum wages (or foreign wages in general) are lower. Countries set their own minimum wage laws in ways that are sensitive to circumstances, and wages in poorer countries are lower for a variety of factors that ultimately reflect lower economic productivity in poorer countries. Most important, unlike greenhouse gas emissions, these labor market differences do not typically generate global market externalities, so there are fewer concerns regarding international policy spillovers, such as leakage and free-riding.
[8] An analysis of the proposed carbon border adjustment mechanism in 2021 showed that four industries (iron and steel, cement and lime, fertilizer, and aluminum) account for about 55 percent of European Union industrial carbon-equivalent emissions, which themselves are about 25 percent of European Union carbon equivalent emissions (European Commission 2021, Figure 7). Note that the proposed mechanism has been expanded beyond the sectors analyzed in the Commission report.

levies would have an incentive to send aluminum from their cleanest (least carbon intensive) plants to Europe, while sending the dirtier products to other countries, a process described as "reshuffling" (Fowlie, Petersen and Reguant 2021).

If the measurement were instead done at the industry level, that would reduce the incentive to reshuffle, but it would also dampen the incentives of individual producers to reduce their carbon emissions—because they would simply be assigned the industry-average assessment regardless. One possible way around the latter problem would be to allow companies to opt for self-certification, charging the remaining companies based on the average emissions of the residual group of companies. Assuming one can measure and monitor both company and total industry emissions, this approach has the potential to lead to efficiency gains, as described in Cicala, Hemous and Olsen (2022).

More generally, one can imagine a carbon border adjustment mechanism leading to broad reshuffling, whereby dirty exports head to countries without carbon border adjustment mechanism at a lower price (potentially increasing demand for such products in those markets) and clean country exports serve the markets of countries with a carbon border adjustment mechanism. In these instances, the aggregate impact on emissions is likely to be small.

If measurement of carbon content is done at a more aggregate level, policy-makers may take mitigation actions in order to reduce the tariffs faced by a subset of industries; we discuss these policy dynamics in more detail below. Still, although carbon border adjustment mechanisms address competitiveness concerns, their effect on emissions will depend quantitatively on how important energy-intensive export markets are for the trading partners of carbon border adjustment countries. The literature (drawing mainly on simulations) tends to find that they have only small effects on emissions, production, and welfare (Böhringer, Balistreri, and Rutherford 2012; Devarajan et al. 2022; Irfanoglu et al. 2015; Branger and Quirion 2014).

Supply Chain Complications

A carbon border mechanism also poses vexing issues surrounding value chains. While carbon border adjustment mechanisms have the potential to address competitiveness issues faced by industries in cost-imposing jurisdictions, they do not address the competitiveness of industries that use those products intensively as inputs. For example, if the European Union adopts its proposed carbon border adjustment mechanism, it will adjust for differences in the carbon price applied to steel imports, but not for automobile imports, at least for the first several years. To the extent EU automobile manufacturers face higher steel prices, they would be at a competitive disadvantage unaddressed by the carbon border adjustment mechanism. Given that many of the most-carbon intensive products (iron/steel, aluminum, chemicals, glass, fertilizers, and so on) can be important inputs for downstream industries, it may prove difficult to completely level the competitiveness playing field in the absence of an economy-wide carbon price and border adjustment.

Carbon Border Adjustments without Carbon Pricing?

Countries that rely on subsidies as the central element of their climate policy do not face the competitiveness concerns that arise from domestic carbon pricing. Their industries do not face increased costs due to government climate change mitigation policies; on the contrary, energy costs paid by industry may be reduced by government subsidies. For example, the United States does not currently impose a nationwide carbon price, and while some U.S. states impose costs on their firms, these jurisdictions do not generally host many firms in energy intensive, traded industries. For example, examining U.S. sources of production of the products targeted for inclusion in the proposed EU carbon border adjustment mechanism—like steel, aluminum, cement and chemicals—the implied average U.S. carbon price is very low, under $1 per ton.

However, once carbon border adjustments are part of the political discussion, domestic actors could use them as an excuse to seek protectionism, even in cases where little "adjustment" is actually required. For example, U.S. industries could claim that their low emissions alone should justify a border adjustment, even though their industries do not face carbon costs, and may even benefit from energy subsidies that lower their input costs. The United States government has made a proposal along these lines for the steel industry, working toward a "green steel deal" with the European Union (as reported in Swanson 2022).[9] However, a carbon border adjustment mechanism in such instances might usefully be relabeled as a "carbon tariff."

Such carbon tariffs are likely to be perceived as unfair abroad, by two sets of jurisdictions. For those jurisdictions that are imposing carbon costs and imposing a carbon border adjustment mechanism as a consequence, a carbon tariff would keep intact any competitive disadvantage faced by their producers relative to U.S. producers. This could unravel efficient policies, by lowering support for cost-imposition abroad, as foreign producers will suspect (justifiably) that a level playing field is impossible. Such producers may seek countervailing subsidies under the argument that subsidies are required to maintain fair competition. Such a dynamic could unravel efficient climate policies and result in timid actions by governments that have little fiscal space for bold programs of subsidization. Other jurisdictions that do not impose their own carbon-pricing regimes may also complain about a U.S. carbon tariff, arguing that such tariffs are little more than protectionism in disguise, given that the U.S. government imposes no carbon price of its own. Finally, a U.S. carbon tariff would do nothing to incentivize further reductions in U.S. emissions.

For these reasons, economic logic suggests only using a carbon border adjustment mechanism in the presence of cost-imposing policies; such limits would also enable the carbon border

[9] The U.S. proposal envisions both the United States and the European Union (alongside other countries that might join the group) levying tariffs on emissions-intensive steel from other countries outside the group (Swanson 2022). However, the steel arrangement has somewhat unique preconditions. For instance, the United States has long protected the steel industry with tariffs through anti-dumping provisions and, in 2017, the unfounded invocation of Section 232, which allowed a levying of broad tariffs on steel and aluminum on national security grounds. In December 2022, the World Trade Organization (WTO) ruled that these tariffs were not consistent with trade rules, but the U.S. Trade Representative stated that the WTO should not judge U.S. national security interests.

adjustment mechanism to be implemented in a manner that was consistent with world trade obligations. While consistency with these rules has admittedly not been central to the policy-making concerns of U.S. policy-makers since 2017, the principles behind World Trade Organization rules nonetheless remain an important source of stability and fairness in the international trading system.

Domestic Policy Dynamics of Carbon Border Adjustments

Perhaps the most intriguing feature of carbon border adjustment mechanisms is not how they shape company decisions about emissions or even the patterns of international trade, but rather how they shape the policy choices of governments that determine the future path of greenhouse gas emissions. The ability to create positive policy spillovers may be a first order determinant of ambitious climate policy.

In the United States, a border adjustment could facilitate the adoption of cost-imposing policies by addressing concerns regarding the erosion of domestic industry competitiveness, carbon leakage, and the free-riding of other countries. Indeed carbon border adjustment has the potential to harness protectionist sentiment toward efficient ends. For example, the steel industry has frequently been successful in seeking tariff protection in recent decades. Some of the rationale for these tariffs has not been well-founded, including recent reliance on national security rationale. But in the presence of carbon pricing, a carbon border adjustment could serve efficiency by equalizing the costs associated with carbon emissions for all producers serving the U.S. market.

In fact, many U.S. industries could gain competitiveness from a price-based approach that included a border adjustment, since U.S. industrial production tends to be less carbon-intensive than that of several of our largest trading partners (Climate Leadership Council, 2020). One report suggested that a $43 per ton carbon tax and accompanying border adjustment may cause U.S. imports to fall considerably, while U.S. steel industry output would expand (CRU Consulting, 2021).

A carbon border adjustment mechanism might enable a useful pivot toward pricing tools as a complement to subsidies in the U.S. government approach to climate mitigation. While most models predict that the U.S. subsidy-based approach to climate policy will be effective, they also predict that this approach will not lead to sufficient emissions reductions, particularly in the industrial sector, strengthening the rationale for at least some carbon price on industrial emissions (Bistline, Mehrotra, and Wolfram 2023). Timilsina (2022) reviews numerous studies that speak to the greater efficiency of price-based mitigation policies.

Moreover fiscal constraints may make it attractive to use carbon pricing as a complementary approach to subsidies. The two policies together can achieve greater emissions reductions at a lower fiscal cost, while also providing revenue to insulate households from increased costs (Roy, Burtraw, and Rennert 2021).

In addition, the clean energy subsidies may change the political economy of price-based approaches, by increasing the size and power of industrial sectors that would also benefit from carbon pricing (including wind, solar, electric vehicles, batteries, nuclear power, carbon sequestration, sustainable aviation fuel, and others), while shrinking the power and market size of the fossil fuel industry. In the end, cost-increasing and cost-reducing policies may be complementary policy instruments. For instance, the European Union has long subsidized the development of clean electricity production, and this groundwork helped enable a stronger carbon pricing system.

Policy Dynamics of Carbon Border Adjustments Abroad

More generally, if carbon border adjustment mechanisms were broadly applied by a wide group of importers, such mechanisms have the potential to induce virtuous policy changes abroad for several reasons. First, if the jurisdiction in question is dependent on carbon-intensive exports to countries that are imposing a carbon border adjustment mechanism, it may find adoption of symmetric carbon pricing (which would eliminate the tariff) advantageous, or it may increase an existing carbon price to lessen the tariff (Bohringer, Carbone and Rutherford, 2016). Even sector-level carbon pricing may be sufficient to turn off the tariff. Second, increased carbon pricing would have the benefit of converting foreign tariff revenue to domestic revenue. If a domestic company has to pay for its carbon content when shipping to a country with a carbon border adjustment mechanism, its payments might as well instead benefit the domestic treasury. Both of these effects depend quantitatively on how important energy-intensive export markets are for the trading partners of countries that are imposing a carbon border adjustment mechanism.

Third, in exporting countries, a foreign carbon border adjustment mechanism could provide political cover and rhetorical arguments for making the transition to cost-imposing policies. For example, Turkiye, which sends nearly half of its exports to the European Union, has considered imposing its own carbon price in response to the EU carbon border adjustment mechanism (Weise 2021). Similarly, the EU adjustment mechanism has also been credited with pushing Russia to announce a carbon neutrality goal and experiment with carbon pricing— before Russia's invasion of Ukraine scrambled trade and political relations (Zabanova 2021). The European Union adjusted the regulations for its proposed carbon border adjustment mechanism to address concerns that countries would implement carbon prices that were only assessed on exports to the European Union, deeming such a scheme a circumvention and ineligible for credit towards the carbon border adjustment mechanism.

Finally, if there is widespread adoption of a carbon border adjustment mechanism, there may also be a symbolic or moral rationale for implementing carbon pricing to qualify for the "in" group and avoid barriers. While the strength of this motive should not be overstated, it might influence those countries that want to be seen as good actors with respect to climate policy.

However, the foreign policy responses to a carbon border adjustment mechanism need not be accommodating. Not all governments abroad will be sanguine about the threat of foreign tariffs;

for example, China, India, Indonesia, and Thailand have suggested that they will oppose carbon border adjustment mechanisms on the grounds that they are protectionist and discriminatory (Böhringer et al. 2022). If some countries launch retaliatory actions in response, this risks a trade war of escalating tariffs, reducing the gains from trade on both sides and harming international cooperative efforts on both climate and other areas of joint concern. Given the many agenda items requiring international cooperation (including security, public health, and tax competition), the downsides of additional trade frictions are substantial, especially at a time when the international trading system is already under strain.

While we have highlighted how the economic argument for carbon border adjustment mechanisms is strongest in the presence of cost-imposing policies, this choice is not strictly dichotomous. Policymakers could choose to adjust the share of domestic emissions subject to a carbon price. For example, a bill proposed in the U.S. Senate would charge a carbon price on U.S. plants whose emissions are above some threshold (currently set at U.S. average emissions), and a corresponding carbon border adjustment mechanism on imports for their carbon emissions above that threshold.[10]

This approach does not resolve the competitiveness concerns of other jurisdictions that impose costs on all carbon emissions, but it does have the advantage of treating all emissions similarly in the domestic market. And, the threshold itself is an important policy dial. As the threshold increases, this approach mimics a carbon tariff with no corresponding domestic cost, since costs are mostly imposed on carbon-intensive imports rather than domestic production. As the threshold goes down and approaches zero, the policy approaches an industry-specific carbon price applying to domestic producers and with an accompanying carbon border adjustment mechanism.

Climate Clubs

Some countries undertake ambitious and costly policies in order to reduce greenhouse gas emissions; others do not. Since climate change is a global phenomenon, no jurisdiction will internalize the externalities associated with greenhouse gas emissions, given that the vast majority of the benefits from emissions reduction efforts benefit those outside their borders. Absent a coordinating mechanism, jurisdictions have a self-interested incentive to do suboptimal amounts of mitigation, leading to a free-riding effect.

For almost 30 years, the main international coordinating mechanism has been the periodic meetings of the UN Framework Convention on Climate Change. However, these meetings have

[10]The Clean Competition Act (S.4355 from the 2021-2022 U.S. Congress) is described at https://www.congress.gov/bill/117th-congress/senate-bill/4355. CRU (2021) reports that steel production in China, the world's largest exporter, are 1.8 and 5 times more emissions intensive than U.S. steel production for flat and long steel products, respectively; thus, carbon fees would be higher for Chinese producers than those in the United States.

emphasized voluntary pledges for reducing carbon emissions, including “nationally determined contributions,” a concept that was central to the “Paris Accord” agreements adopted in 2016. There is no enforcement mechanism to address countries that either commit too little or do not meet their commitments. Since the Paris Accord, countries have fallen woefully short, both making commitments that aren’t sufficiently ambitious and failing to enact policies that meet existing commitments (Climate Action Tracker 2022).

This free-rider concern led Nordhaus (2015) to propose a climate club, whereby ambitious jurisdictions could group together and seek to prevent free-riding behavior by levying penalties on insufficiently ambitious jurisdictions. In theory, ambition need not take the form of a carbon price; other measures that reduce emissions could be considered equivalent. In practice, Nordhaus cautioned that relying on price mechanisms would make implementation far more straightforward. Otherwise, it would be difficult to measure the relative stringency of countries’ policies, and any such judgements could swiftly become contentious.

In a climate club, penalties against low-ambition countries could take the form of a broad tariff on all imports, which has advantages relative to a carbon border adjustment mechanism. It is administratively simpler, because there is no need to measure the carbon content of imports. It is also less prone to trade reshuffling in response, because all goods from non-club countries would face the tariff.

Differences with a Carbon Border Adjustment Mechanism

Climate clubs differ from carbon border adjustments in that they are not meant to level the playing field for any particular good. Instead, they seek to encourage policy ambition by penalizing insufficiently ambitious countries with an across-the-board tariff. Like carbon border adjustments, they are capable of channeling protectionist sentiment toward potentially helpful ends, but there are also risks that the climate would be used as an excuse to impose tariffs that are not justified on climate policy grounds.

Climate clubs don’t have generalizable fiscal implications. If countries adopt carbon pricing to join the club, that will generate substantial revenues for those countries, but choosing to pursue an ambitious program of subsidies to join the club would have the opposite budgetary effect. Carbon border adjustments are designed to fall on only a small number of sectors that are carbon-intensive in production, so they have relatively minor revenue impacts. However, a climate club could conceivably enact broader tariffs, and thus would generally raise more revenue than a carbon border adjustment mechanism – though far less than an economy-wide carbon price.

By the same logic, climate clubs should have a stronger incentive effect on “out” countries to enact climate policies, because non-adoption comes with larger trade barriers that affect a country’s entire export sector, not just carbon-intensive products. Also, the rhetorical or symbolic motives for joining the climate club could also be stronger, since the club would be more explicitly designed to distinguish "good" (climate ambitious) countries from "bad" (free-riding) countries.

Challenges of Climate Clubs

Climate clubs face a number of practical challenges and concerns. First, it is likely to be difficult for countries to agree on how to measure the rough equivalence of policy ambition. Some countries may prefer a carbon tax while others prefer a cap-and-trade approach—and countries' carbon price choices are likely to differ. Further, some national economies may already be emitting less carbon per person, perhaps as a result of their industrial mix or because they already have a substantial amount of hydroelectric or nuclear power. Such countries may feel that their current policies are already sufficiently ambitious, despite limited new policy action. Further, in a real-world situation, membership "in" or "out" of a climate club will likely reflect political power and alliances, not just dispassionate measures of real climate policy action.

Perhaps the most difficult problems arise if some countries wish to certify their membership in the climate club by subsidies for green energy, rather than carbon pricing. For example, the United States might seek to claim its place as a "high ambition country" based on the vast expenditures on clean energy tax credits and investments in the 2021 and 2022 legislation. But in this situation, the climate club does nothing to address policy concerns about competitiveness. For example, within the set of high-ambition countries, cost-reducing locations will have an advantage. Because climate clubs would implement a broad-based tariff without considering underlying policy differences across "in" countries, they cannot remedy industry competitiveness concerns (for trade-exposed energy-intensive industries) absent much greater policy harmonization.

Indeed, in the presence of heterogeneous policy choices, where some jurisdictions impose costs and others subsidize, it is not possible to address both types of policy spillovers (competitiveness and free-riding) with a single remedy. A carbon border adjustment will not completely address free-riding, and a climate club will not address competitiveness.

Second, because the goal is not to equalize policy-induced costs in particular industries (like a carbon border adjustment mechanism), the appropriate tariff level to impose outside the club becomes a political judgment. It does not take much imagination to realize that such judgements could swiftly become fraught. Related, if tariffs are significant, a climate club made up of primarily higher-income countries imposing broad tariffs on lower-income countries would strike many as punitive or unfair, which could weaken the moral impetus to join. These issues are discussed in the following section.

Third, countries outside of the climate club may respond by launching retaliatory trade measures, which could spark counter-retaliation and a trade war. These incentives would be even larger with a carbon club than with a carbon border adjustment mechanism due to the larger impact of the tariffs. In the extreme, a climate club could bifurcate the world such that countries in the club primarily trade with one another and countries outside the club likewise primarily trade with one another.

Finally, the rules of a climate club may also be hard to reconcile with commitments under the World Trade Organization agreements. Unlike a carbon border adjustment, the tariffs in a climate club are not designed to treat both foreign and domestic producers alike in the home market. While some argue that climate issues should be put before the arcane details of trade rules (for example, Rodrik 2022), it is important to avoid trade tensions that might ultimately risk both environmental objectives as well as the gains from trade. The challenge would be to modernize World Trade Organization rules to allow countries the freedom to take heterogenous emissions reduction strategies, without undermining the long-held objectives of the world trading system.

In theory, both carbon border adjustment mechanisms and climate clubs could operate without any tariffs actually coming into effect. Indeed, the ideal outcome would be for policy adoption abroad to forestall the use of tariffs, leading to an upward harmonization of climate policy. In that event, the threat of tariffs would remain just that. The example of Turkiye (described above) provides one real-world illustration of this process at work. But it remains unclear if such a “leveling-up” scenario is realistic.

Implications for Low-Income Countries

Poorer countries tend to face greater risks from climate change, as simulations show emerging markets (on average) bear higher relative costs in terms of economic disruption and loss of life (for example, Carleton et al. 2022). Poorer countries also frequently lack the resources and fiscal space to undertake climate change mitigation efforts, and given the opportunity costs of fiscal resources in low-income countries, their efforts often entail greater absolute levels of sacrifice. Finally, the existing stock of greenhouse gases in the atmosphere were mostly caused by economic activities in richer countries, so fairness suggests they should bear the brunt of the costs.

Both carbon border adjustment mechanisms and climate clubs risk harming poorer countries in the event that their goods face tariffs abroad. Opportunities for export-led growth will be diminished, and tariffs will reduce the gains from trade. Böhringer, Carbone and Rutherford (2018) show that carbon border adjustment mechanisms have important distributional consequences, reallocating abatement costs toward those countries facing levies. These considerations raise questions about the price of admission to the climate club, or what policy actions might be required in order to turn off a carbon border adjustment mechanism or club tariff.

One option is to require less policy action from poorer countries. IMF staff suggest a carbon pricing floor that varies with level of development (Parry, Black and Roaf 2021). One scenario they consider would require price floors of $75 per ton for advanced economies, $50 per ton for higher-income emerging economies, and $25 per ton for low-income emerging economies; they show how these policies could complement existing “nationally determined contribution” commitments under the Paris agreement.

One could also imagine exempting the poorest countries from carbon border adjustment mechanisms or club tariffs, alongside earmarking revenues from border measures for a fund targeting emissions reductions in poorer countries. Since low-income country emissions are a relatively small fraction of the world total, significant gains can be achieved even when exempting the poorest countries. As of 2019, the 28 countries that the World Bank classifies as low-income generate 4 percent of world carbon emissions; even the 82 countries that are either low-income or lower-middle income (Venezuela was not reported) generate only about 25 percent of world emissions.

Poor countries have a lot to gain from successful international cooperation around emissions mitigation. In addition to bearing significant costs from inaction, they stand to benefit from the cost reductions and technological innovation associated with the clean energy transition, enabling their own emissions reductions to be done at lower cost when the time comes. Cost-imposing measures abroad are no threat to their competitiveness. While cost-reducing measures could give some foreign industries an advantage, they also generate greater scale and innovation in clean energy sectors.

Discussion

Climate policies are unsurprisingly heterogeneous. National economies specialize in different industries and generate wide-ranging standards of living, and their governments face varying political constraints, fiscal constraints, and circumstances. When countries’ climate policies vary, those policies generate spillovers. Cost-imposing jurisdictions fear carbon leakage and negative competitiveness effects, and high-ambition countries fear that low-ambition countries will free-ride on their sacrifices.

International trade plays an important role in national decision-making about climate change mitigation efforts. About 25 percent of all greenhouse gas emissions are embodied in traded goods, and an economy’s carbon “footprint” may differ substantially based on whether it is measured in production terms (as is typical) or in consumption terms (Wiedmann and Lenzen 2018). For example, China’s economy produces more carbon-intensive products than it consumes, whereas the opposite is true for the United States. On average, lower-income countries produce more carbon-intensive products than they consume, while higher-income countries consume more carbon-intensive products than they produce (Liu et al. 2020; Zhu et al. 2018; Wood et al. 2020). International trade also has more general effects on carbon emissions, by altering the scale and composition of production as well as the spread of innovation (Copeland and Taylor 2004; Copeland, Shapiro, and Taylor 2022).

Ideally, countries would coordinate border measures in a way that encourages positive policy action, rather than conflict. An ideal border adjustment or climate club would end up levying few tariffs, instead urging trading partners to respond to enforcement mechanisms with greater mitigation efforts. At present, four jurisdictions--United States, China, India, and the European Union--account for about half of world carbon emissions. Thus, any coordination effort should pay close attention to the incentives of these jurisdictions, while also building a system that can address wide-ranging economic circumstances across the globe.

Trade negotiations can potentially serve as invaluable tools to further climate aims. The current trade policy structure works against climate change mitigation, since trade barriers (both tariff and non-tariff) are far higher for low-carbon industries than for high-carbon industries. This provides large implicit subsidies to emissions-intensive production, relative to cleaner production (Shapiro 2021). New rounds of trade negotiation can aim to correct these perverse incentives, while lowering or eliminating trade barriers on goods, services, and technology that are needed to support clean energy adoption and innovation. Even if carbon border adjustment mechanisms or climate clubs result in some tariff increases, this can be done alongside broader efforts at green trade liberalization and a rebalancing of current tariffs structures.

International cooperation on climate mitigation policy can be enhanced through carrots as well as sticks (Jakob et al. 2022). Market access, including access to scarce supplies of key raw materials needed to produce clean energy, is an important carrot that can work alongside carbon border adjustments (or other sticks) to encourage countries to participate in cooperative solutions. In addition, subsidizing countries should commit to ensuring that the benefits of their investments in clean energy help the world adopt cleaner technologies, by working to facilitate knowledge spillovers across national boundaries through reduced barriers on clean energy trade and investment. This vision offers opportunities to make progress on climate without undermining the world trading system, which has generated enormous gains benefitting billions of people. Beyond these reforms, the World Trade Organization can continue to serve its enduring purpose: allowing countries to access the myriad gains from trade by ensuring predictable rules and collaborative solutions to global collective action problems.

These central themes - the inevitability of diverse policy actions, the nature of policy spillovers, and the ideal policy responses to address such spillovers - will define the world’s ability to address climate change in an orderly fashion.

References

Aldy, Joseph E., and William A. Pizer. 2015. "The Competitiveness Impacts of Climate Change Mitigation Policies." *Journal of the Association of Environmental and Resource Economists* 2 (4): 565–95. https://doi.org/10.1086/683305.

Athey, Susan, Rachel Glennerster, Nan Ransohoff and Christopher Snyder. 2021. "Advance Market Commitments Worked for Vaccines. They Could Work for Carbon Removal, Too." *Politico*, December 21, 2021. https://www.politico.com/news/agenda/2021/12/22/carbon-removal-advance-market-commitments-525988

Besley, Timothy and Torsten Perrson. 2014. "Why Do Developing Countries Tax So Little?" *Journal of Economic Perspectives* 28 (4): 99-120.

Bistline, John, Neil Mehrotra, and Catherine Wolfram. 2023. "Economic Implications of the Climate Provisions in the Inflation Reduction Act." *Brookings Papers on Economic Activity.* Brookings Institution. March. https://www.brookings.edu/bpea-articles/economic-implications-of-the-climate-provisions-of-the-inflation-reduction-act/

Bistline, John, Geoffrey Blanford, Maxwell Brown, Dallas Burtraw, Maya Domeshek, Jamil Farbes, Allen Fawcett, Anne Hamilton, Jesse Jenkins, Ryan Jones, Ben King, Hannah Kolus, John Larsen, Amanda Levin, Megan Mahajan, Cara Marcy, Erin Mayfield, James McFarland, Haewon McJeon, Robbie Orvis, Neha Patankar, Kevin Rennert, Christopher Roney, Nicholas Roy, Greg Schivley, Daniel Steinberg, Nadejda Victor, Shelley Wenzel, John Weyant, Ryan Wiser, Mei Yuan, Alicia Zhao. 2022. "Emissions and Energy System Impacts of the Inflation Reduction Act of 2022." Working paper.

Böhringer, Christoph, Edward J. Balistreri, and Thomas F. Rutherford. 2012. "The Role of Border Carbon Adjustment in Unilateral Climate Policy: Overview of an Energy Modeling Forum Study (EMF 29)." *Energy Economics* 34 (December): S97–110. https://doi.org/10.1016/j.eneco.2012.10.003.

Böhringer, Christoph, Jared C. Carbone, and Thomas F. Rutherford. 2016. "The Strategic Value of Carbon Tariffs." *American Economic Journal: Economic Policy* 8 (1): 28-51. http://dx.doi.org/10.1257/pol.20130327.

Böhringer, Christoph, Jared C. Carbone, and Thomas F. Rutherford. 2018. "Embodied Carbon Tariffs." *The Scandinavian Journal of Economics* 120 (1): 183–210. https://doi.org/10.1111/sjoe.12211.

Böhringer, Christoph, Carolyn Fischer, Knut Einar Rosendahl, and Thomas Fox Rutherford. 2022. "Potential Impacts and Challenges of Border Carbon Adjustments." *Nature Climate Change* 12 (1): 22–29. https://doi.org/10.1038/s41558-021-01250-z.

Branger, Frédéric, and Philippe Quirion. 2014. "Would Border Carbon Adjustments Prevent Carbon Leakage and Heavy Industry Competitiveness Losses? Insights from a Meta-Analysis of Recent Economic Studies." *Ecological Economics* 99 (March): 29–39. https://doi.org/10.1016/j.ecolecon.2013.12.010.

Carleton, Tamma, Amir Jina, Michael Delgado, Michael Greenstone, Trevor Houser, Solomon Hsiang, Andrew Hultgren, et al. 2022. "Valuing the Global Mortality Consequences of Climate Change Accounting for Adaptation Costs and Benefits*." *The Quarterly Journal of Economics* 137 (4): 2037–2105. https://doi.org/10.1093/qje/qjac020.

Cicala, Steven, David Hemous, and Morton Olsen. 2022. "Adverse Selection as a Policy Instrument: Unraveling Climate Change." Working paper. http://www.stevecicala.com/papers/unraveling/unraveling_climate_change_draft.pdf.

Climate Action Tracker (Climate Analytics and NewClimate Institute, 2022); https://climateactiontracker.org/global/cat-emissions-gaps/

Climate Leadership Council. 2020. "America's Carbon Advantage." Report. https://clcouncil.org/reports/americas-carbon-advantage.pdf.

Congressional Budget Office. 2022. "Congressional Budget Office Cost Estimate." https://www.cbo.gov/system/files/2022-08/hr5376_IR_Act_8-3-22.pdf.

Copeland, Brian R, Joseph S Shapiro, and M Scott Taylor. 2022. "Globalization and the Environment." In *Handbook of International Economics Volume 5.*, 100.

Copeland, Brian R, and M.Scott Taylor. 2004. "Trade, Growth and the Environment." *Journal of Economic Literature*, March, 7–71.

Credit Suisse. 2022. "U.S. Inflation Reduction Act – A Tipping Point in Climate Action." Credit Suisse ESG Report, Treeprint. Washington DC. https://www.cbo.gov/system/files/2022-08/hr5376_IR_Act_8-3-22.pdf.

CRU Consulting. 2021. "Leveraging a Carbon Advantage: Impacts of a Border Carbon Adjustment and Carbon Fee on the U.S. Steel Industry." https://clcouncil.org/reports/leveraging-a-carbon-advantage.pdf?v1.

Devarajan, Shantayanan, Delfin S. Go, Sherman Robinson, and Karen Theilfelder. 2022. "How Carbon Tariffs and Climate Change Can Slow Global Warming." PIIE Working Paper 22-14. September.

Edmonds, James, Sha Yu, Haewon Mcjeon, Dirk Forrister, Joseph Aldy, Nathan Hultman, Ryna Cui, Stephanie Waldhoff, Leon Clarke, Stefano De Clara, And Clayton Munnings. 2021. "How Much Could Article 6 Enhance Nationally Determined Contribution Ambition Toward Paris Agreement Goals Through Economic Efficiency?" *Climate Change Economics* 12(02). https://doi.org/10.1142/S201000782150007X

European Commission. 2021. "Proposal for a Regulation of the European Parliament and of the Council Establishing a Carbon Border Adjustment Mechanism." 2021/0214 (COD). Brussels.

Fowlie, Meredith, Claire Peterson, and Mar Reguant. 2021. "Border Carbon Adjustments When Carbon Intensity Varies Across Producers: Evidence from California." *AEA Papers and Proceedings* 111 (May): 401-405. https://www.aeaweb.org/articles?id=10.1257/pandp.20211073.

Furman, Jason. 2023. "Comment on 'Economic Implications of the Climate Provisions in the Inflation Reduction Act'." *Brookings Papers on Economic Activity.* Brookings Institution. March.https://www.brookings.edu/wp-content/uploads/2023/02/2b_20230330-BPEA-climate-furman-comment.pdf

Go, Jiyeong. 2022. "EU and Japan Lash out at 'Discriminatory' U.S. Green Subsidies." *FDi Intelligence (Financial Times)*, November 15, 2022. https://www.fdiintelligence.com/content/news/eu-and-japan-lash-out-at-discriminatoryus-green-subsidies-81649.

Goulder, Lawrence, Marc A.C. Hafstead, GyuRim Kim, and Xianling Long. 2019. “Impacts of a Carbon Tax across U.S. Household Income Groups: What Are the Equity-Efficiency Trade-Offs?” *Journal of Public Economics* 175: 44–64.

Grubb, Michael, Nino David Jordan, Edgar Hertwich, Karsten Neuhoff, Kasturi Das, Kaushik Ranjan Bandyopadhyay, Harro van Asselt, Misato Sato, Ranran Wang, William A. Pizer, and Hyungna Oh. 2022. “Carbon Leakage, Consumption, and Trade." *Annual Review of Environment and Resources*, 47(1): 753-795.

Horowitz, John, Julie-Anne Cronin, and Hannah Hawkins. n.d. “Methodology for Analyzing a Carbon Tax.”

International Monetary Fund, and OECD. 2021. “Tax Policy and Climate Change.” Report for the G20 Finance Ministers and Central Bank Governors.

Irfanoglu, Zeynep Burcu, Juan P Sesmero, and Alla Golub. 2015. “Potential of Border Tax Adjustments to Deter Free Riding in International Climate Agreements.” *Environmental Research Letters* 10 (2): 024009. https://doi.org/10.1088/1748-9326/10/2/024009.

Jakob, Michael, Stavros Afionis, Max Åhman, Angelo Antoci, Marlene Arens, Fernando Ascensão, Harro van Asselt, et al. 2022. “How Trade Policy Can Support the Climate Agenda.” *Science* 376 (6600): 1401–3. https://doi.org/10.1126/science.abo4207.

Jaffe, Adam B., Richard G. Newell, and Robert N. Stavins. 2005. “A Tale of Two Market Failures: Technology and Environmental Policy.” *Ecological Economics.* 54 (2): 164–74. https://doi.org/10.1016/j.ecolecon.2004.12.027.

Jessop, Simon, Seham Eloraby, and Valerie Volcovici. 2022. “IMF Chief Says $75/Ton Carbon Price Needed by 2030.” *Reuters*, November 7, 2022.

Kaufman, Noah. 2023. “Should the Inflation Reduction Act End the Dream of a National Carbon Price?” Center for Global Energy Policy. https://www.energypolicy.columbia.edu/should-the-inflation-reduction-act-end-the-dream-of-a-national-carbon-price/

Kleimann, David, Niclas Poitiers, André Sapir, Simone Tagliapietra, Nicolas Vernon, Reinhilde Veugelers, and Jeromin Zettelmeyer. 2023. “How the EU Should Answer the U.S. Inflation Reduction Act.” Bruegel Policy Brief. 23 February. https://www.bruegel.org/policy-brief/how-europe-should-answer-us-inflation-reduction-act

Le Maire, Bruno, and Robert Habeck. 2022. “For a European Green Industrial Policy.” Government Press Release. https://presse.economie.gouv.fr/20122022-for-a-european-green-industrial-policy/.

Levinson, Arik. 2023. “Are Developed Countries Outsourcing Pollution?” *Journal of Economic Perspectives*, this volume.

Liu, Zhu, Jing Meng, Zhu Deng, Ping Lu, Dabo Guan, Qiang Zhang, Kebin He, and Peng Gong. 2020. “Embodied Carbon Emissions in China-U.S. Trade.” *Science China Earth Sciences* 63 (10): 1577–86. https://doi.org/10.1007/s11430-019-9635-x.

Nemet, Gregory F. 2019. *How Solar Energy Became Cheap: A Model for Low-Carbon Innovation.* Routledge.

Nordhaus, William. 2015. “Climate Clubs: Overcoming Free-Riding in International Climate Policy.” *American Economic Review* 105 (4): 1339–70. https://doi.org/10.1257/aer.15000001.

OECD. 2021. "Effective Carbon Rates 2021 Pricing Carbon Emissions through Taxes and Emissions Trading." OECD Series on Carbon Pricing and Energy Taxation.

———. 2022. "Pricing Greenhouse Gas Emissions: Turning Climate Targets into Climate Action." OECD Series on Carbon Pricing and Energy Taxation. https://doi.org/10.1787/e9778969-en.

Parker, George, Andy Bounds, and Aime Williams. 2022. "Britain Joins EU in Criticising Biden's Green Subsidies Package." *Financial Times*, December 22, 2022. https://www.ft.com/content/21fe9241-5e1b-409e-8d6e-98f2e4d06793?emailId=b30d2e5a-5ffa-4653-8fec-c7b3fbb68a45&segmentId=13b7e341-ed02-2b53-e8c0-d9cb59be8b3b.

Parry, Ian. 2021. "Five Things to Know about Carbon Pricing." *IMF Finance and Development*, September, 10–11.

Parry, Ian, Simon Black, and James Roaf. 2021. "Proposal for an International Carbon Price Floor Among Large Emitters." IMF Staff Climate Notes 2021/001.

Penn-Wharton Budget Model. "Update: Budgetary Cost of Climate and Energy Provisions in the Inflation Reduction Act." 27 April 2023. https://budgetmodel.wharton.upenn.edu/estimates/2023/4/27/update-cost-climate-and-energy-inflation-reduction-actRodrik, Dani. 2022. "Climate Before Trade." Project Syndicate Commentary.

Roy, Nicholas, Dallas Burtraw, and Kevin Rennert. 2021. "Cost Analysis and Emissions Projections under Power Sector Proposals in Reconciliation." Resources for the Future Issue Brief 21-15.

Shapiro, Joseph S. 2021. "The Environmental Bias of Trade Policy*." *The Quarterly Journal of Economics* 136 (2): 831–86. https://doi.org/10.1093/qje/qjaa042.

Singhania, Monica, and Neha Saini. 2021. "Demystifying Pollution Haven Hypothesis: Role of FDI." *Journal of Business Research* 123 (February): 516–28. https://doi.org/10.1016/j.jbusres.2020.10.007.

Swanson, Ana. 2022. "U.S. Proposes Green Steel Club That Would Levy Tariffs On Outliers." *New York Times*, December 7, 2022.

Timilsina, Govinda R. 2022. "Carbon Taxes." *Journal of Economic Literature* 60 (4): 1456–1502. https://doi.org/10.1257/jel.20211560.

U.S. Department of the Treasury. 2023. "General Explanations of the Administration's Fiscal Year 2024 Revenue Proposals."

Weise, Zia. 2021. "EU's Looming Carbon Tax Nudged Turkey Toward Paris Climate Accord, Envoy Says." *Politico*, November 6, 2021.

Wiedmann, Thomas, and Manfred Lenzen. 2018. "Environmental and Social Footprints of International Trade." *Nature Geoscience* 11: 314–21.

Wood, Richard, Michael Grubb, Annela Anger-Kraavi, Hector Pollitt, Ben Rizzo, Eva Alexandri, Konstantin Stadler, Dan Moran, Edgar Hertwich, and Arnold Tukker. 2020. "Beyond Peak Emission Transfers: Historical Impacts of Globalization and Future Impacts of Climate Policies on International Emission Transfers." *Climate Policy* 20 (sup1): S14–27. https://doi.org/10.1080/14693062.2019.1619507.

World Bank. 2014. "Statement: Putting a Price on Carbon." https://www.worldbank.org/en/programs/pricing-carbon#Statement.

World Bank. 2022. “What You Need to Know About Article 6 of the Paris Agreement.” https://www.worldbank.org/en/news/feature/2022/05/17/what-you-need-to-know-about-article-6-of-the-paris-agreement

Zabanova, Yena. 2021. “Navigating Uncharted Waters: Russia’s Evolving Reactions to the CBAM and the European Green Deal.” Heinrich Böll Foundation.

Zhu, Yongbin, Yajuan Shi, Jing Wu, Leying Wu, and Wen Xiong. 2018. “Exploring the Characteristics of CO2 Emissions Embodied in International Trade and the Fair Share of Responsibility.” *Ecological Economics* 146 (April): 574–87. https://doi.org/10.1016/j.ecolecon.2017.12.020.

PIIE PETERSON INSTITUTE FOR INTERNATIONAL ECONOMICS