ECONOMY-WIDE APPROACHES

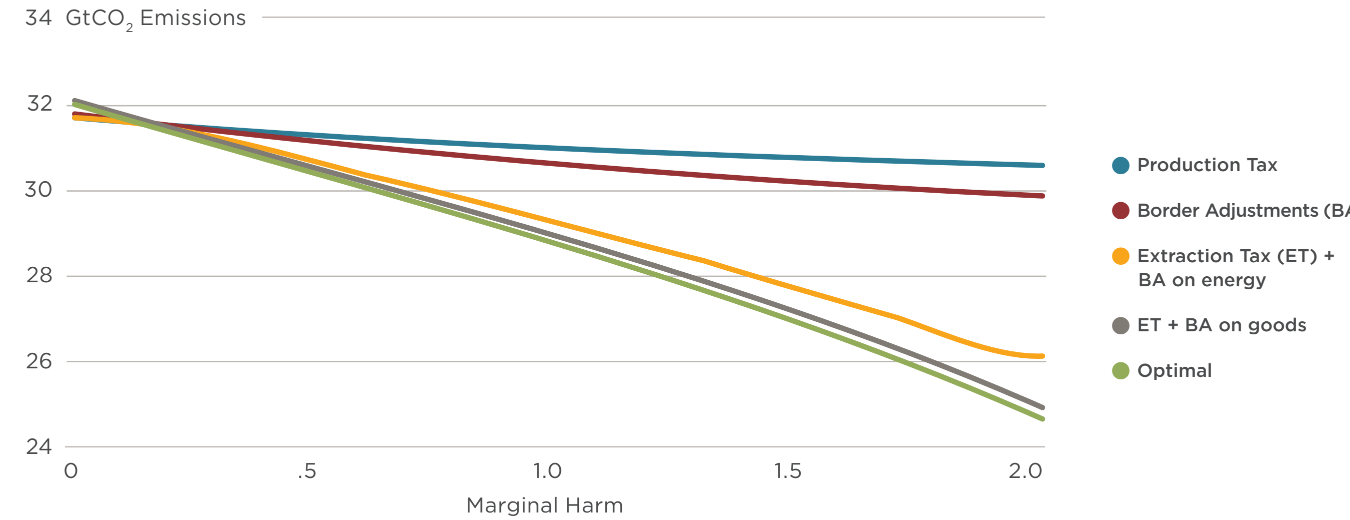
A Solution to the Leakage Problem

David Weisbach, *Walter J. Blum Professor of Law, University of Chicago Law School*
Samuel Kortum, *James Burrows Moffatt Professor of Economics, Yale University Department of Economics*

If the United States or a subset of countries restrict emissions of carbon dioxide but other countries do not, energy-intensive industries may simply relocate offshore to countries with fewer restrictions on emissions. Relocated industries would continue to pollute, and the United States would lose those industries. This effect, known as leakage, is one of the central reasons that the United States has, so far, failed to act on climate change at a level anywhere near what is needed.

CHAPTER IN A CHART

Optimal Policy



Source: Authors' calculations.

In the absence of a uniform, global price on carbon, the most commonly proposed policy to address leakage is imposing what are known as "border adjustments." Border adjustments are combinations of import tariffs and export rebates. The import tariff is a tax on emissions in the foreign country from production of the imported good. It ensures that imports face the same tax as goods produced domestically. The export rebate gives back any carbon taxes paid domestically, so that goods sold abroad face the same tax as other goods sold in the foreign country. Every major carbon-pricing proposal in the United States in recent years has included border adjustments in one version or another.

Research shows that carbon taxes paired with border adjustments can reduce leakage and modestly reduce carbon emissions. But, border adjustments pose serious legal and administrative problems, not least that they are difficult to calculate, easy to avoid, and possibly constitute an illegal trade barrier.

There is a different approach, however, that faces none of these drawbacks and at the same time is more effective at reducing emissions. The approach is to impose the carbon tax on domestic extraction of fossil fuels, rather than on domestic emissions, combined with border adjustments on imports and exports of energy, but not other goods. Rather than imposing the border adjustments at the same rate as the extraction tax, however, the border adjustments are imposed at a lower rate. The net result is a combination of a tax on domestic extraction and a tax on emissions from domestic production. This combination of taxes controls leakage effectively and legally and reduces emissions much more effectively than conventional approaches. Rather than devoting time to a hard-to-enforce, possibly illegal border adjustment system, the Biden administration should work with Congress to consider this new, targeted approach.

Heart of the Problem

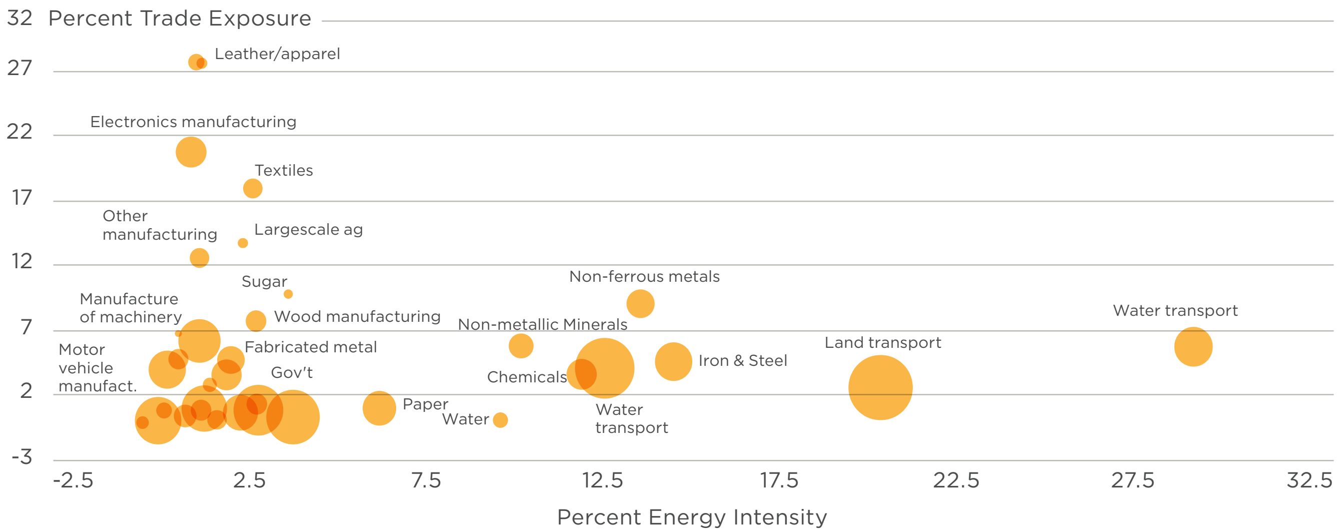
Carbon pricing and leakage

Existing carbon pricing systems worldwide, and most proposals for carbon prices in the United States, impose a price on emissions wherever the smokestack or tailpipe is located. For example, if a steel plant is located in the United States, the steel producer would have pay a tax on (or buy permits for) its emissions.[1] The tax does not apply to emissions abroad: a Canadian steel producer would not be subject to a U.S. carbon tax even if the steel it produces is ultimately used in the United States. Similarly, a U.S. steel producer who exports its steel to Canada would pay the U.S. tax even though the steel is used abroad.

1 This chapter will, for the most part, discuss carbon taxes. The analysis would be the same if the United States were to impose a cap and trade system. That is, none of the differences between taxes and cap and trade systems affect the analysis here.

FIGURE 1

Trade Exposure v. Energy Intensity



Source: Elliott et al., (2013).

This structure raises the risk that a domestic steel producer could relocate abroad to a jurisdiction that has a lower, or even a zero, price on emissions and ship the steel into the United States, thereby avoiding the tax. Similarly, it raises the risk that domestic producers lose market share in foreign markets to competitors who do not face the same carbon price. Leakage—this shifting of emissions offshore—may make domestic carbon pricing futile because emissions reductions at home would be replaced by emissions increases abroad. Moreover, the steel producer is forced to operate in a less-preferred location and whatever benefits there were to the United States of having the steel produced domestically are lost.

Leakage is likely concentrated in just a few industries: those that are energy intensive *and* trade exposed. Figure 1 provides a sense of which industries are prone to leakage. It plots industries in the Annex B countries[2] by their exposure to trade and their energy intensity (with the size of the bubbles indicating the size of the industry). As can be seen, most industries in the United States are either not highly dependent on energy, or, if they are, are not significantly exposed to trade: there is nothing in the upper-right corner of Figure 1. For most, a carbon price will not significantly increase their costs. For others, the likely effects on trade are small. For example, land transport is energy intensive but cannot move abroad. Electronics are highly trade-exposed but not energy intensive. Only a small number of industries are both energy-intensive and exposed to trade and, therefore, at risk for leakage.

Within this so-called EITE—energy-intensive, trade-exposed—sector, leakage will depend on where major competitors are located. If major competitors are in countries that also impose significant emissions restrictions, leakage may not be a problem. If the major competitors of an EITE industry are in countries with few emissions restrictions, however, leakage may be more serious.

Table 1 shows U.S. imports, by origin, of the five most energy-intensive, trade-exposed industries. For each industry, it lists the five largest countries of origin as well as the fraction of total imports that comes from Annex B countries, the developed countries that are most likely to impose emissions restrictions.

Just 35.5 percent of U.S. chemical imports are produced in Annex B countries, indicating that chemical production would be relatively vulnerable to leakage.[3] Imports of cement, paper, and aluminum, by contrast, are mostly from Annex B countries, making leakage in those industries less likely. The table suggests that leakage may not be as serious a problem as it first seems, even for EITE industries. Most competitors of EITE industries are in countries that are likely to impose emissions restrictions.

2 Annex B refers to a section of the Kyoto Protocol, an international climate agreement signed in 1997. The countries listed in Annex B, typically wealthy, industrialized countries, committed to specific, binding emissions reductions.

3 Trinidad, however, accounts for 31.4 percent of chemical imports, due to its access to inexpensive natural gas. The United States could work to limit leakage to Trinidad through trade negotiations rather than through the structure of a carbon-pricing system.

TABLE 1

U.S. Imports of EITE Goods by Origin, 2015

Steel Source	%	Aluminum Source	%	Chemicals Source	%	Paper Source	%	Cement Source	%
EU	22.3	Canada	46.7	Trinidad	31.4	Canada	39.7	Canada	39.0
Canada	15.3	China	12.4	Canada	21.0	China	19.6	EU	26.7
Korea	11.5	OPEC	9.2	Korea	10.1	EU	18.0	China	11.6
China	10.5	EU	9.2	EU	8.3	Mexico	6.8	Korea	7.9
Brazil	7.1	Russia	5.8	OPEC	5.3	Korea	2.9	Mexico	5.0
Annex B	**50.4**		**59.4**		**35.5**		**61.7**		**70.3**

Source: Kortum and Weisbach (2017).

Because concern about leakage has been so central to U.S. climate policy debates, there have been a large number of estimates of the likely size of leakage. Most are done using large scale, computable general equilibrium models, and start by assuming a carbon tax has been implemented in most developed countries (such as the Kyoto Protocol Annex B countries) that reduces global emissions by about 10 percent. The models estimate leakage under this scenario to be between 8 percent and 20 percent. That means that for every hundred tons of emissions reductions from a carbon price in the United States, there is an increase of between eight and twenty tons in other parts of the world. This is modest in terms of the overall tax, but likely large in the case of particular industries.

Border adjustments

The most commonly proposed solution to leakage is to impose border adjustments. To understand border adjustments, it is useful to think of there being three different places to impose a carbon price. Most carbon prices are imposed on emissions, that is on the smokestack. This tax can be thought of as a *production tax* because the tax is imposed on emissions from production. A second option is to impose an *extraction tax* on the mining of fossil fuels. Almost all fossil fuels that are extracted are eventually burned. Therefore, the carbon molecules can be taxed as they come out of the ground rather than when they are released into the atmosphere. Finally, it could be imposed as a *consumption tax* on the use of energy or goods produced with energy. Gasoline taxes work this way: consumers pay gasoline taxes at the pump.

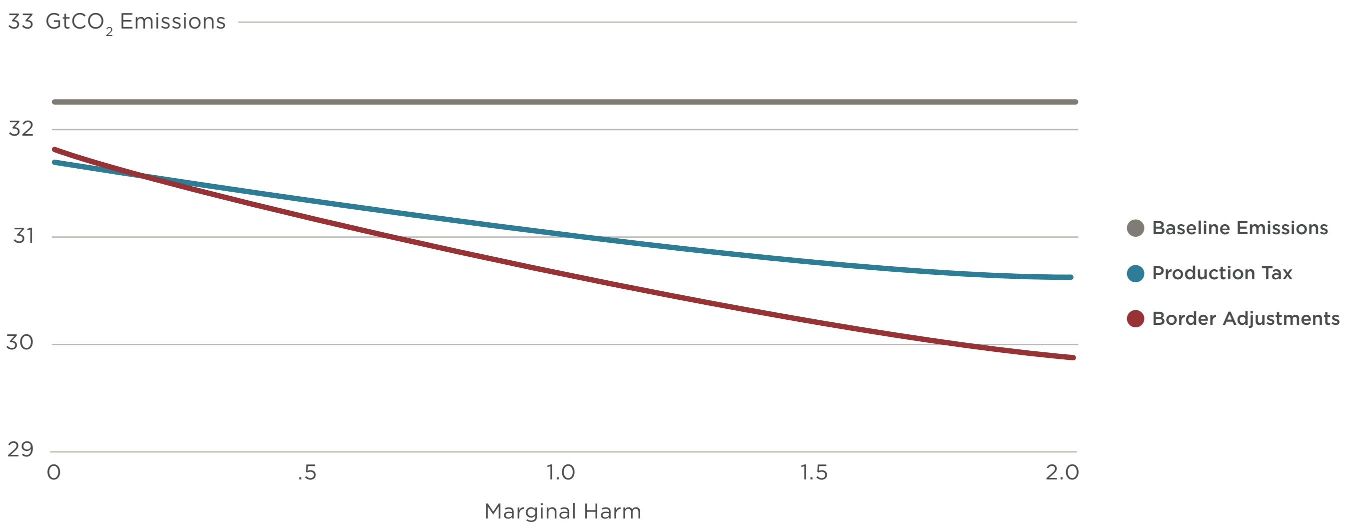
In a closed economy, these three taxes would have the same effect. With minor exceptions, all fossil fuels that are extracted are used to produce energy for the production of goods or services, so extraction and production would be the same. Any resulting goods and services are consumed domestically, so production and consumption would be the same.

With trade, however, these taxes are no longer the same. Energy that is extracted in the United States might be exported, rather than used here. And producers in the United States might use energy that is imported. An extraction tax in these circumstances is no longer the same as a production tax. Similarly, goods that are produced here may be exported and consumers may buy imported goods. Production taxes are no longer the same as consumption taxes. The choice among the three taxes now means that policymakers are choosing different tax bases.

Border adjustments can be thought of as shifting among these tax bases. For example, consider an extraction tax with a border adjustment on energy. Any energy that is extracted here and used in production here would bear a tax, while any energy that is exported and used in production abroad would not because the extraction tax would be rebated on export. And any energy that is imported and used here in production would be taxed on import. Therefore, an extraction tax plus border adjustments is just a tax on the use of energy in domestic production.

FIGURE 2

Emissions Reductions Under Conventional Taxes and Border Adjustments



Source: Authors' analysis.

The same logic holds for a tax on domestic production with border adjustments on goods. Any goods produced in the United States and consumed here would bear a tax. Exported goods would not because the production tax would be rebated at the border. And goods that are imported and consumed here would have a tax imposed at the border. Adding border adjustments to a tax on domestic production shifts it to a tax on domestic consumption. Border adjustments shift the tax downstream.

As mentioned, carbon prices around the world, as well as proposals for carbon prices in the United States, are for the most part imposed on emissions from domestic production. Modeling suggests that border adjustments to these taxes would be modestly effective at reducing leakage, perhaps by about a third.[4]

Figure 2 show a simulation of the effects of border adjustments on global emissions. The simulation, which will be returned to throughout this chapter, is of a model of the effects of carbon taxes and trade. The model assumes that one region of the world imposes a carbon price and the rest of the world does not[5] and can be used to illustrate the set of carbon policies that are best for the people in the taxing region, taking into account their effects on the economy and global emissions.

4 Aldy (2017) provides a succinct summary of these modeling efforts.

5 For further details, see "Optimal Unilateral Carbon Policy" at http://kortum.elisites.yale.edu.

The simulation of the model used here assumes that carbon prices are imposed in the Organization for Economic Cooperation and Development (OECD). It is calibrated to global trade and emissions data and uses available empirical estimates of parameters such as the responsiveness of energy supply to changes in prices. The model allows an arbitrary set of carbon prices (including border adjustments) to be imposed in the taxing region, so it can simulate the effects of different policies that policymakers might choose to apply.

The x-axis in Figure 2 is the marginal harm to the OECD from global emissions. It can be thought of as, roughly, the social cost of carbon measured as a percentage of the price of energy. A value of one means that the harms from a ton of CO_2 are equal in dollar terms to the price of the carbon content of a unit of energy. (The same definition applies to all other figures so labeled.) The y-axis is global emissions measured in gigatons of CO_2 ($GtCO_2$).

The carbon prices in each case are the prices that the OECD would choose to maximize its welfare, conditional on the assumption that it has chosen to impose that particular policy. For example, the production tax line shows the emissions reductions that the OECD would achieve assuming that it has chosen to impose a production tax at a tax rate that is best for the OECD (taking into account leakage, harms from climate change, and other effects).

Baseline OECD emissions are 32.3 $GtCO_2$. With marginal harm of two, emissions go down under the production tax by 1.7 $GtCO_2$ to 30.6 $GtCO_2$. Adding border adjustments allows the OECD to reduce global emissions by another 0.7 $GtCO_2$ to 29.8 $GtCO_2$, a real but modest improvement.

Though border adjustments produce some benefits in terms of emissions reductions, they are not without controversy. Critics argue that they constitute an illegal barrier to trade under World Trade Organization (WTO) rules because a border adjustment taxes the method of a good's production rather than the carbon physically in the good. WTO law is unclear on whether border adjustments on methods of production are allowed, and if not, whether exceptions for environmentally motivated border taxes apply. While the majority view is that the WTO would not hold border adjustments on goods to be illegal, there is considerable uncertainty. Were U.S. policymakers to pursue this approach, it could take years to resolve these legal questions in Geneva with unknown trade repercussions.

Border adjustments on goods would also be incredibly difficult to impose in any accurate and comprehensive manner. There is no straightforward way to determine the emissions associated with an imported good. Imagine a shipload of automobiles arriving in Los Angeles. Each automobile will have parts from many different countries with the parts assembled in yet another set of countries. Those parts may have been produced using various technologies and fuel sources under a number of environmental regimes. And the mix of parts, countries, and fuel sources will be different for each type of vehicle and possibly for different model years of the same vehicle. A regulatory regime that purported to reflect the emissions generated by producing each car—let alone every other good passing through the port—would be impossibly complex, difficult to enforce, and expensive to maintain.

As a result, border adjustment proposals, including all bills in the 116th Congress, limit them to a narrow set of goods, most often raw materials such as steel and chemicals, excluding complex final goods such as automobiles. For similar reasons, they often limit border adjustment to imports from or exports to countries with a low or inadequate carbon price.

Yet, even these simplified versions pose significant implementation challenges. Raw materials of the same type are produced using a wide variety of production

FURTHER READING

Carbon Taxes & Border Adjustments

The Design of Border Adjustments for Carbon Prices

National Tax Journal

Border adjustments levy a carbon fee on imports, while exports from a country with a carbon tax have their carbon price refunded at the border. As a result, domestic consumers pay the baked-in price of a carbon tax for goods produced domestically and on imports.

Optimal Unilateral Carbon Policy

Working Paper

The central concern with imposing a unilateral climate policy is that it will lead to leakage. A model shows that there is an optimal policy that allows the taxing region to exploit international trade to expand the reach of its climate policy.

methods and emissions profiles. Moreover, there are thousands of kinds of raw materials, so proposals for border adjustments would aggregate them into broad categories, such as all organic chemicals or all rolled steel. Individual items in any given category, however, may have emissions profiles that deviate substantially from the category average. Determining which countries have low or inadequate carbon prices would be controversial. At best, border adjustments would be narrow and crude.

Border adjustments would also be prone to avoidance. For example, rather than shipping raw materials, exporters from low tax countries could ship final goods or partially finished goods. They could switch fuel sources, using clean sources of fuel for exports to the United States and dirty sources for their own use. They could also transship goods through countries with high carbon taxes (but no border adjustments), making the goods appear as if they were from the high-tax country rather than the low-tax country. In such a complex system, the opportunities for mischief are legion.

A crude system that is subject to avoidance would generate endless disputes. For example, importers would argue about the classification of goods or the method of attributing emissions to their production technology and fuel source. Policymakers would need to establish a robust bureaucracy, promulgating product categories, emissions attribution methods, rules to prevent avoidance, and methods of dispute resolution.

In short, despite their apparent political appeal, border adjustments have significant flaws. They only modestly improve the performance of a production tax, reducing leakage by about half. They raise legal problems. And they are exceptionally difficult to administer. There are good reasons that they are controversial.

There is, however, a better way. It is simpler, reduces emissions and controls leakage much more effectively, and is clearly legal.

What To Do

U.S. policymakers should pursue a better approach to the problem, building off four key ideas.

INSIGHT 1

Extraction, consumption, & production taxes affect energy prices—and leakage—differently

Leakage arises because of changes in the price of energy seen by actors in different countries. For example, with conventional carbon prices, production shifts to regions without a carbon price because energy is less expensive there. Extraction taxes and production and consumption taxes, however, have opposite effects on the price of energy. Extraction taxes—taxes on the supply of energy—raise the global price of energy while both production and consumption taxes—taxes on the demand for energy—lower it. Policymakers can exploit this fact when designing a carbon tax system.

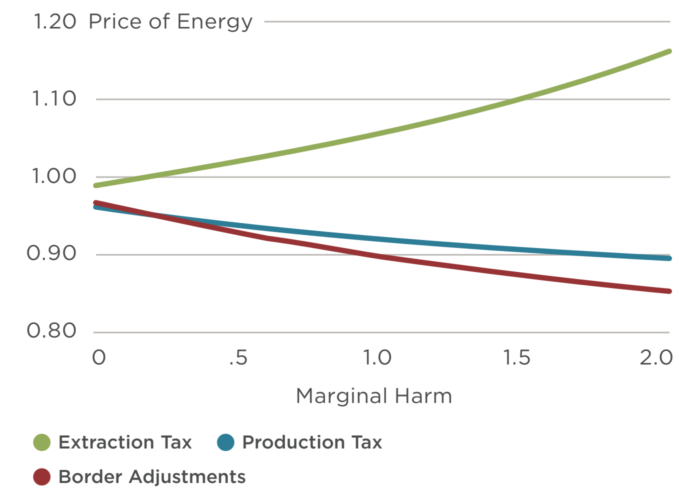
To understand why extraction taxes raise the price of energy, suppose that the United States imposed a tax on domestic extraction. Energy extractors would receive their sales price minus the tax. Because extraction will be less profitable, they will extract less. A lower supply means prices go up. This effect will be mediated to some extent by an increase in extraction in other countries: a higher energy price makes foreign extractors want to extract more. Unless the increase in supply by foreign extractors completely offsets the domestic reduction, however, extraction taxes raise the global price of energy.

Compare that to the more typical carbon tax on emissions from domestic production. Producers' cost of energy is the market price of energy *plus* the tax. They pay more for energy inputs and, therefore, will demand less. They will shift to cleaner technologies and sell fewer energy-intensive products. As a result, the price of energy goes down. This means that foreign producers see a lower cost for energy inputs. They expand production (partially offsetting the lower demand), resulting in traditional leakage.

Taxes on the consumption of goods produced with energy operate the same way. Consumers demand fewer energy-intensive goods and producers respond by adopting cleaner technology. The resulting lower demand for energy lowers its global price.

Figure 3 shows how extraction, production, and consumption taxes (i.e., production taxes with border adjustments) change the price of energy. A value of 1 indicates that the price of energy has not changed. As can be seen, extraction taxes increase the price of energy while production and consumption taxes reduce it.

FIGURE 3
Effects of Three Taxes on the Price of Energy



Source: Authors' calculations.

Border adjustments shift production taxes to consumption taxes, but both operate the same way on the price of energy because they are both taxes on the demand for energy. This means that border adjustments are not helpful in mitigating the core source of leakage, which is the reduction in the price of energy.[6] They do not address the core problem.

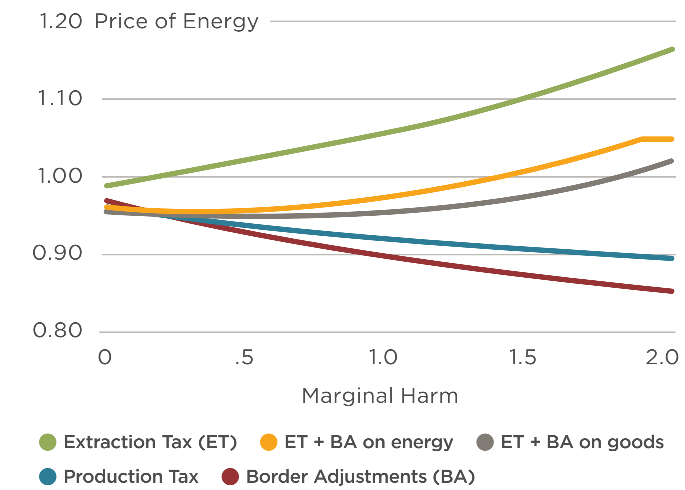
INSIGHT 2

Combining border adjustments can have complementary effects

The second key insight is that border adjustments can be imposed at a lower rate than that of the underlying carbon tax, and that doing so effectively combines two different tax systems. If policymakers start with an extraction tax and impose border adjustments just on energy at a lower rate, the effect is to shift that portion of the extraction tax to production. Suppose for example, the United States were to impose an extraction tax at $100/ton of CO_2 and a border adjustment on imports and exports of energy at $60/ton. The border adjustment shifts $60 of the tax to production, leaving $40 on extraction. A similar effect

6 They help to the extent that foreign producers sell to consumers in the United States because those producers see the after-tax price of energy. While this helps, it does not offset the core dynamics of production and consumption taxes.

FIGURE 4
Effects of Hybrid Taxes on the Price of Energy



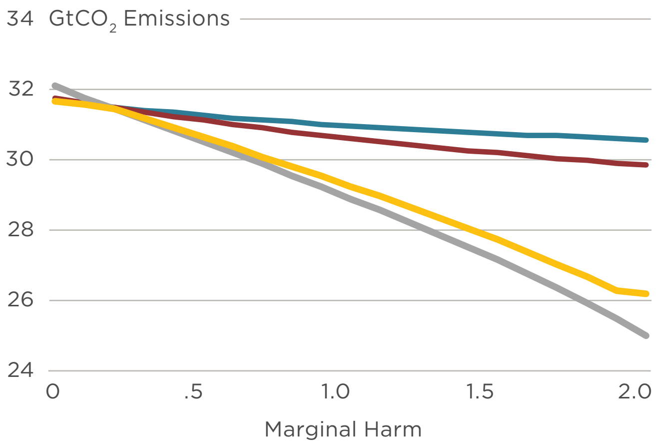
Source: Authors' calculations.

arises with border adjustments to production taxes: a border adjustment at a lower rate than the production tax shifts that portion of the tax to consumption. As a result, we can use what we will call partial border adjustments to combine the various taxes whatever way is preferred.

These two insights can be combined to produce a simple and effective carbon price. By combining an extraction tax (which pushes energy prices up) with a partial border adjustment on energy, the United States (or a broader taxing coalition) can effectively combine taxes—an extraction tax and a production tax, a tax on supply and a tax on demand—that push the price of energy in opposite directions. By moderating the effects on the price of energy, this combination controls leakage. Policymakers could also combine an extraction tax with a partial border tax on both energy and goods, effectively creating a combination of an extraction tax and a consumption tax. This combination similarly moderates the effects on the price of energy.

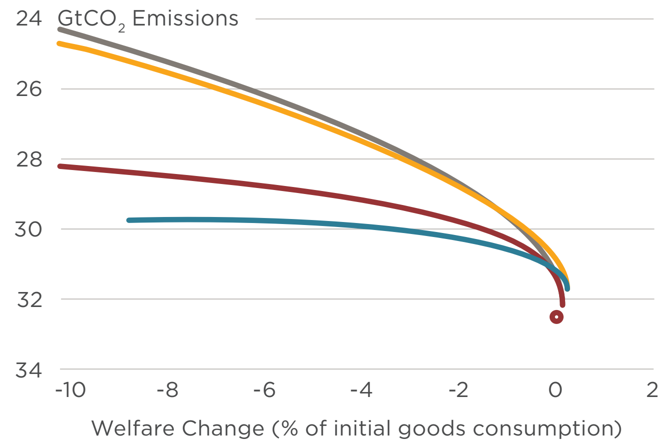
Figure 4 illustrates. It adds two taxes to those shown in Figure 2: an extraction tax combined with a production tax, and an extraction tax combined with a consumption tax. For example, the combination might be an extraction tax at $60 per ton and a production tax at $40 per ton. The hybrid taxes moderate the effects on the price of energy relative to an extraction tax alone. Energy prices go up

FIGURE 5
Emissions Reduction with Extraction Tax Hybrids



Source: Authors' calculations.

FIGURE 6
Relative Costs of Emissions Reductions Under Different Tax Systems



Source: Authors' calculations.

with the hybrids rather than down (as they do under production and consumption taxes), but they go up less than under a pure extraction tax.

The effect of these hybrid taxes on emissions is dramatic. Figure 5 compares the emissions reductions with a traditional production tax, or production tax and border adjustments, with the hybrid taxes. A combination of extraction and production taxes reduces emissions by 6.2 GtCO_2 to 26.1 GtCO_2.[7] The combination of extraction and consumption taxes reduce emissions by 7.3 GtCO_2, to 25 GtCO_2. The hybrids are much more effective at reducing emissions than the traditional production tax or a production tax plus border adjustments. This is because they operate to control the price of energy in ways that more traditional approaches cannot.

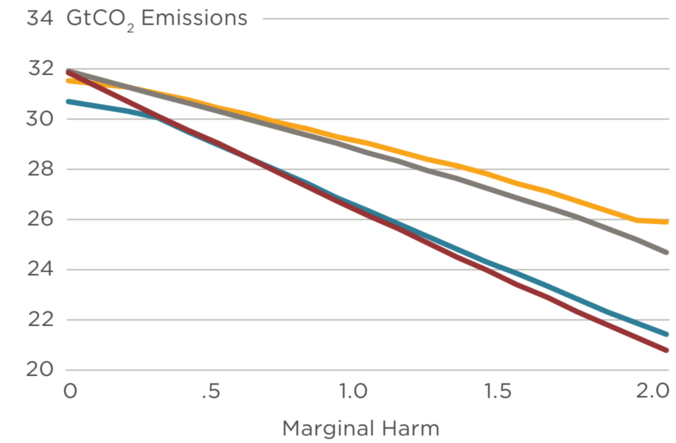
An alternative way to compare the taxes is to look at the costs of achieving a global emissions target for a given tax system. Figure 6 illustrates. The x-axis shows the costs of an emissions policy in terms of lost welfare, a measure in this model akin to a reduction in gross domestic product (GDP) normalized by spending on goods. The y-axis is global emissions. (Note that because the y-axis is a "good" and fewer emissions is better, going up the y-axis means fewer emissions.) Reading vertically, it says, for example, at a cost of 4 percent, a production tax reduces emissions from the 32.3 GtCO_2 to just under 30 GtCO_2. Adding border adjustments improves the emissions reductions achievable at that cost to about 29 GtCO_2. The combination of an extraction tax and a production tax reduces emissions to 27.3 GtCO_2 and the extraction/consumption hybrid to 27.1 GtCO_2. The differences between conventional approaches and the hybrid approaches get even larger as spending on emissions reductions rises in the model. At an 8 percent cost, the hybrid taxes achieve almost twice the emissions reductions of a conventional tax on emissions from production.

For U.S. policymakers interested in implementing a carbon price, the lessons of this model are clear. The combination of an extraction tax with border adjustments on energy (the extraction/production hybrid) or with border adjustments on energy and goods (the extraction/consumption hybrid) easily outperforms conventional carbon taxes.

Moreover, border adjustments on energy do not suffer from the problems with border adjustments highlighted above. They are easy to implement and clearly legal.

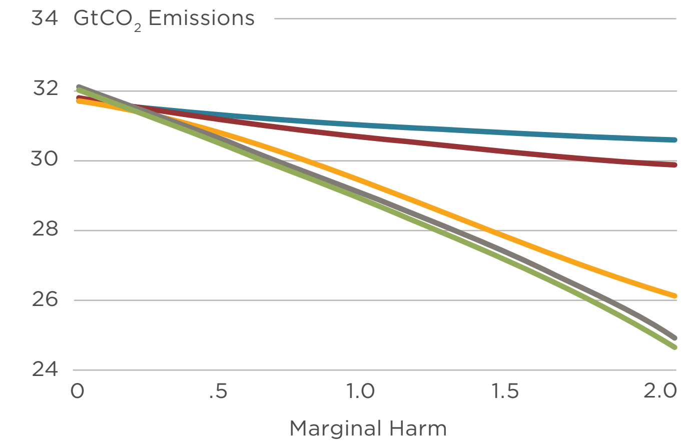
7 The kink in the line at marginal harm equals 1.9 is due to a corner solution where a particular source of emissions reaches zero and cannot be reduced further.

FIGURE 7
Emissions Reductions: OECD + China



Source: Authors' calculations.

FIGURE 8
Optimal Policy



Source: Authors' calculations.

To implement them, regulators only need to know the carbon content of imported or exported fuels, which is easy to calculate. And compared to overall imports and exports, the volumes are smaller and easier to track. They are legal because the border adjustment would be on the actual carbon crossing the border, not on the production process.[8] Border adjustments on energy are not an unrealistic and elusive goal.

These first two insights on their own provide a solution to the leakage problem. The third and fourth insights show how to improve on this solution.

INSIGHT 3
Coalition size and composition influences effectiveness and cost

Expanding the taxing coalition reduces leakage and makes the tax more effective. Figure 7 illustrates. It shows each of the two hybrid taxes, for two cases: the prior case of the OECD as the taxing region and a new case adding China to the coalition. Adding China makes the taxes perform much better than with just the OECD as the taxing region. Emissions now go down by 10.6 GtCO_2 to 21.7 GtCO_2 with the extraction/production combination and by 11.2 GtCO_2 to 21.1 GtCO_2 with the extraction/consumption combination.

The cost differences between the two hybrid taxes are much smaller with China in the taxing coalition. The reason is that adding China adds more production than consumption to the tax base. There is, as a result, less (or no) benefit to adding border adjustments to goods (and, thereby shifting the tax base to consumption). In this group, an extraction tax with border adjustments only on energy does just as well (in terms of welfare) and would be far simpler to implement. This result confirms the conventional wisdom that expanding the number of countries in any taxing coalition is important, and suggests that Congress should work with the U.S. Trade Representative and the State Department to recruit partner countries and build a carbon pricing system that has the flexibility to absorb them.

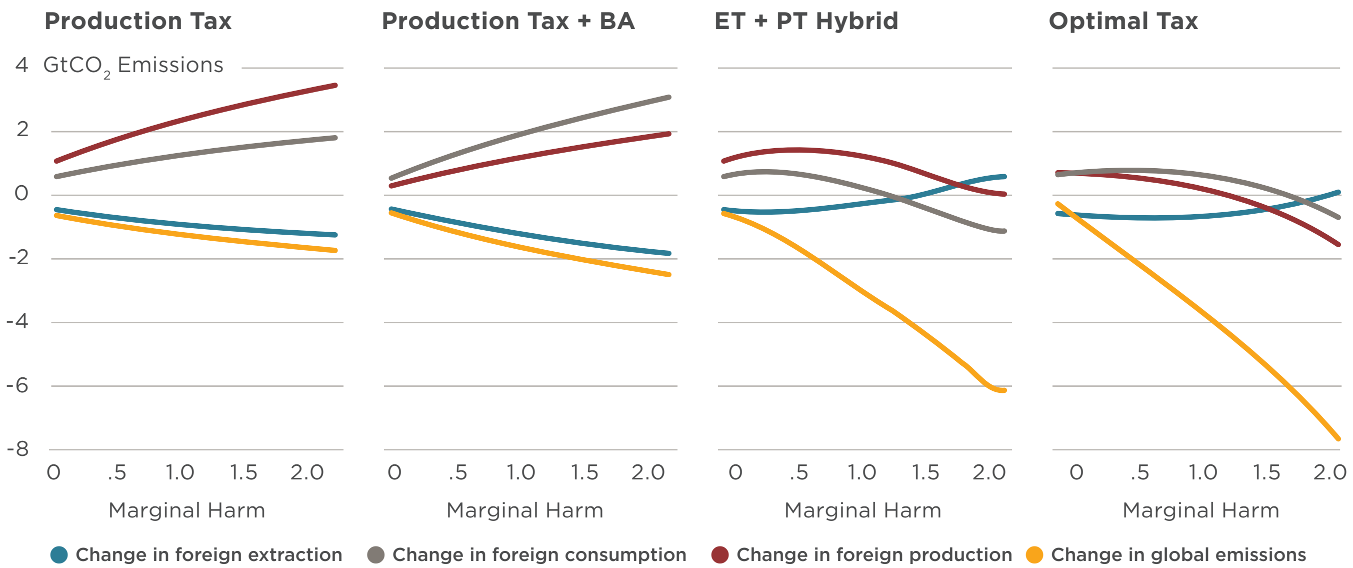
INSIGHT 4
Broadening the carbon tax base increases its effectiveness

The final insight is that expanding the tax base to other countries, even those outside the taxing coalition, tends to further reduce emissions and leakage. The intuition is

8 If the taxing coalition is such that there remains a benefit to the extraction/consumption hybrid, a possible middle ground might impose border adjustments on energy and on a subset of goods that are particularly energy intensive and trade exposed.

FIGURE 9

Effects on Location



Source: Authors' calculations.

straightforward: the broader the tax base the more it has to operate on and the less room for leakage.

The United States can, through careful design of its carbon policy, expand the tax base to production and consumption outside of the taxing coalition. One way to do this is to impose border taxes on imports of goods but not rebate taxes on export. As discussed, this policy taxes both domestic production (regardless of where consumed) and domestic consumption (regardless of where produced). The tax base is broader and more effective.

Without a rebate on export, however, domestic producers may worry about their ability to compete in foreign markets. One way to address these concerns while maintaining the broad tax base is to offer exporters per-unit rebates of taxes rather than rebates based on prior taxes paid. For example, the United States could rebate the average carbon tax that was paid for goods, possibly on a per industry basis. This approach gives domestic producers an incentive to reduce emissions while allowing them to compete in foreign markets on a level playing field.[9] And it helps expand the carbon pricing base by helping to ensure that the United States maintains its exports even after imposing a carbon price.

In fact, the simulation results shown in this chapter indicate that an even more aggressive export policy is desirable. The United States should seek to expand, rather than just maintain, its export margin. It should do so through a policy of tax rebates and if necessary, subsidies, for exports so that it exports more with the carbon policy in place than without. Expanding exports in this way expands the carbon price and allows greater emissions reductions. It is the environmentally best policy and the policy that is best for the United States.

Figure 8 shows the effects of the last insight (returning to the assumption that the OECD is the taxing coalition). It illustrates what the model suggests is "optimal" policy: the combination of taxes and subsidies that maximizes domestic well-being. It combines an extraction tax, border adjustments (at a lower rate) on energy, a border adjustment on imports of goods, and a policy for the export of goods that expands exports through a combination of taxes and subsidies on exported goods. In terms of emissions reductions, it performs better than the simpler hybrids shown above, but not dramatically so.

Whether this more elaborate policy is worth pursuing depends on the costs of imposing import taxes on goods and whether those taxes and the export policy are legal. These issues need more examination. Pending the resolution of these issues, the best policy is to simply tax extraction and impose border adjustments on energy (but not goods) at a lower rate than the underlying extraction tax. This achieves most of the benefits of more complex policies at a much lower cost.

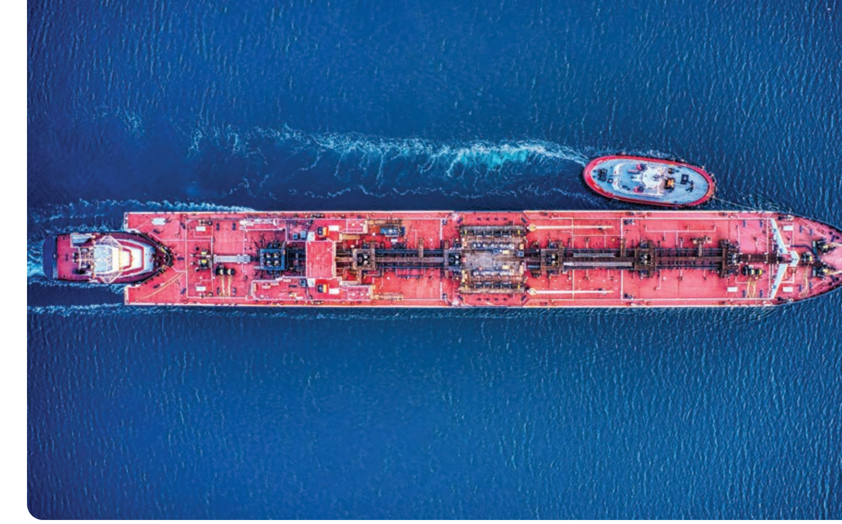
One final way to examine these policies is to look directly at how they change the levels of extraction, production, and consumption in the non-taxing regions. This helps gauge the potential level of leakage—how much the alternative policies are causing a shift in activities, such as an increase in production, in the rest of the world. Figure 9 compares four different taxes: traditional production taxes (far left), production taxes plus border adjustments (second from left), the hybrid of an extraction tax and a production tax (second from right), and the optimal tax (far right). The effects on location are smaller for the hybrid and optimal taxes than either of the traditional taxes. The taxes that do better in terms of emissions reductions and well-being—the hybrid and the optimal policies—do so in part because they control location shifts and leakage more effectively.

Closing Argument

The traditional approach of taxing domestic emissions and imposing border adjustments to control leakage suffers from a fundamental flaw. The key to controlling leakage and to tax system design is moderating the effects of the tax on the price of energy. A tax on domestic emissions and that tax combined with border adjustments, however, both push the price of energy in the same direction: down. As a result, these policies do not, and cannot, perform well on a global basis. Moreover, border adjustments are complex and legally questionable.

A better approach is to tax domestic extraction and to combine that with border adjustments (at a lower rate than the extraction tax) on energy and possibly goods or a subset of goods. It takes advantage of the offsetting effect on the price of energy from extraction taxes and either production or consumption taxes. This approach is simpler to administer, achieves much better outcomes, and is clearly legal.

Even better results can be reached by adding border adjustments on the import of goods and an export policy that retains or expands U.S. exports. Whether these additions are desirable depends on how much complexity and legal uncertainty they would introduce.



Reducing the possibility that high-emitting industries move overseas will be critical to ensuring the effectiveness of any carbon-pricing policy.

Pricing carbon is the most efficient way to reduce emissions and address climate change. The design of the pricing system, particularly in light of the potential for leakage, however, can make important differences in how well it functions. As the incoming Biden administration and the new Congress consider new carbon pricing proposals, they should keep these insights for their design in mind.

REFERENCES

Aldy, Joseph E. "Frameworks for Evaluating Policy Approaches to Address the Competitiveness Concerns of Mitigating Greenhouse Gas Emissions." *National Tax Journal* 70, No. 2 (2017).

Elliott, Joshua, David A. Weisbach, Ian Foster, Sam Kortum & Todd Munson. "Unilateral Carbon Taxes, Border Tax Adjustments, and Carbon Leakage." *Theoretical Inquiries In Law* 14, No. 207 (2013).

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

Kortum, Sam, and David Weisbach. "The Design of Border Adjustments for Carbon Prices." *National Tax Journal* 70, No. 2 (2017).

Kortum, Sam and David Weisbach. "Optimal Unilateral Carbon Pricing." *Working paper*. http://kortum.elisites.yale.edu/

9 This approach has been suggested previously by Fischer and Fox (2012).