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Carbon Policies, Competitiveness, and Emissions Leakage

An International Perspective

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Resources for the Future, in collaboration with Sophia University, and the U.S. Environmental Protection Agency (EPA), held a two-day workshop on February 22–23 entitled *Carbon Policies, Competitiveness, and Emissions Leakage: An International Perspective.* The workshop focused on the effectiveness and international impacts of carbon pricing policies and provisions aimed at mitigating the emissions leakage and adverse competitiveness impacts that a pricing policy could create. Researchers from around the world, who are actively studying these issues, including analysts from the United States, Canada, the European Union, and Japan, shared the results of their research. In the context of trade and competitiveness issues, key topics included the role and effectiveness of output-based rebating, auctioning, and grandfathering in allocating emissions permits, as well as border carbon adjustments (BCAs) and other policy tools to mitigate emissions and production leakage and adverse competitive impacts. Additionally, participants compared the leakage and competitiveness impacts of unilateral and multilateral pricing policies and examined the short-run, industry-level effects that could arise at the inception of a domestic carbon pricing policy

Climate Policy Modeling: A Background on Current Approaches, Policies, and Concepts

Most models of the long-term impacts of current climate policy proposals make use of a *top-down* modeling approach. These computable general equilibrium models use detailed data on inter-industry transactions and international trade for multiple countries. The models allow for agents and firms to make optimizing decisions (e.g., utility maximization for households and profit maximization for firms) that determine the effects of changes in the broader economy. Models differ in a variety of ways, including whether they allow for intertemporal optimization (e.g., models in which firms make decisions over the course of many years versus those that provide a snapshot of an economy in a base year), the number of countries included, and the level of sectoral disaggregation. The level and nature of disaggregation, as well as the unilateral or multilateral nature of the policy responses, are important issues in analyzing the effects of carbon pricing policies on competitiveness and emissions leakage.

Several different policy responses to concerns about competitiveness and leakage are under consideration in the United States and abroad. In the United States, the three main bills are H.R. 2454 (Waxman–Markey), S. 1733 (Kerry–Boxer), and S. 2877 (Cantwell–Collins). Although the bills differ in many respects; all of them include some provisions designed to combat emissions leakage and/or impacts on energy-intensive and trade-exposed[1] (EITE) industries. In H.R. 2454 and S. 1733, permits would be set aside for local distribution companies (LDCs) and EITE industries, with allocations to EITE industries distributed in an output-based rebate system. BCAs could apply starting as soon as 2020 based on a series of findings to be made by the president. S. 2877 has generally similar provisions, although the size and precise design of the rebates are not stipulated and the BCAs would commence near the start of the program in 2013. Aside from the BCA in S. 2877, provisions for domestic industries are primarily intended to compensate for their inability to compete internationally as a result of domestic carbon pricing. In particular, trade-exposed industries would be given "targeted relief funds" to compensate for average sectoral costs incurred per unit of output as a result of domestic carbon pricing. This approach differs from that of the other two bills largely because it does little to compensate domestic energy-intensive industries for the production cost increases that will be incurred for domestic sales. The border adjustment on imports would diminish the incentive for leakage abroad, and the targeted relief funds would mitigate the competitive disadvantage that U.S. exporters would experience under the imposition of a unilateral carbon pricing policy.

Outside of the United States, the European Union is approaching the end of Phase II of its Emissions Trading Scheme (E.U. ETS), and similar policy discussions are underway about the design of Phase III. Whereas permits in the initial phases of the E.U. ETS were allocated for free by member states, in the third phase the European Union is likely to see a combination of auctioning and free allocations. As proposed, Phase III would include full auctioning for the power sector after 2012 and gratis allocations for the sectors most at risk for leakage. The remaining industries covered under the third phase would receive some form of transitional assistance, likely in the form of free permits granted for 80 percent of an established baseline with this declining to 30 percent in 2020 and phasing out completely in 2027. Unlike the United States, the European system involves a modified grandfathering system, rather than output-based rebates. Whereas current U.S. proposals involve *economy-wide* caps on emissions, the E.U. ETS is a sector-based program. The third phase of the E.U. ETS, however, will expand sectoral coverage, likely adding the aviation, petrochemicals, ammonia, and aluminum sectors.

Of course, the United States and the European Union are not the only economies with concerns about good policy design. Canada has been considering implementing a carbon price mechanism for some time, and recent discussions in Japan also focus on potential policy measures to prevent leakage and adverse competitive impacts that would arise under the implementation of a carbon pricing policy. With these concerns in mind, one needs clarity in understanding the different potential policy tools.

Broadly speaking, output-based rebating, auctioning, and grandfathering are the main proposals for allocating emissions permits under a cap-and-trade program. Of these alternatives, output-based rebating is the main proposal for dealing with emissions leakage and competitiveness concerns, and border adjustments are also considered. However, a variety of different types of output-based rebating and BCAs can be undertaken. For instance, a number of output-based rebates and allocation schemes have been discussed, including the following.

1. Output-based allocations based only on direct emissions: Under this approach, allocations are based on the average emissions per unit of output from direct fuel consumption in a given sector.

2. Output-based allocations based only on indirect emissions: This approach is similar to (1) above, except that the average emissions include estimates of those arising indirectly through the use of electricity in production. These might be considered to offset the effects on EITE industry competitiveness from a cap on the power sector.

3. Output-based allocations based on total emissions: This approach is similar to what is found in H.R. 2454, where allocations to EITE industries are roughly based on the total direct and indirect emissions content per unit of output for a given sector.

4. Output-based allocations based on historical industry emissions shares: Under this approach, each sector gets a share of the cap in proportion to its historical emissions share, and the average allocation equals that number of permits divided by total output. Under this approach, the average rebate is not updated to reflect changes in emissions intensities.

5. Output-based allocations based on historical industry value-added shares: This approach is similar to (4) except that industry-level allocations are based on value-added shares.

Specific BCAs under discussion include the following.

1. Border adjustment for imports: Importers are required to purchase allowances according to a metric of the carbon intensity of the imports. Carbon content can be determined based on:

    a. actual emissions intensity (noting that data requirements for foreign emissions intensities are challenging to acquire);
    b. domestic emissions intensity (which applies comparable costs to imports); or
    c. best practice emissions intensity (which allows a modest adjustment, but with minimal data and ensuring that no foreign producer is overcharged).

Note that in all of these cases, calculations may include direct emissions, indirect emissions, or both.

2. Border adjustment for imports and exports: In addition to the above, rebates would be given to exports according to domestic emissions intensities. Full border adjustment would effectively implement a consumption-based carbon regulation.

The Competitiveness and Leakage Effects of Current Climate Proposals in the United States

The first part of the conference examined the effects of current U.S. climate policy proposals on industry production costs, net exports, terms of trade, and emissions leakage. The first presentation was on the *Interagency Report*, released last December by the U.S. EPA, Department of the Treasury, and other federal agencies. The presentation focused on scenarios of U.S. unilateral policy and a multilateral policy that includes both output-based rebating to EITE industries and allocations to LDCs in the electricity sector and natural gas distribution companies of the type contained in H.R. 2454. Overall, the *Interagency Report* found that the EITE and LDC allocations were largely effective in mitigating the adverse impacts of a carbon pricing policy on marginal production costs. Three of the five EITE industries examined had near zero increases under a pricing policy with both types of allocations, and two industries had net decreases in marginal production costs. Concerning trade effects, the presentation emphasized that a unilateral U.S. policy, without any rebates for EITE industries or utilities, would result in increases in net imports in the chemicals, nonmetallic minerals, iron and steel, and nonferrous metals industries ranging from 1.3 to 2.4 percent. Expanding climate policy coverage beyond the United States to include other developed countries, albeit without rebates, lowers the increase in net imports significantly for nonmetallic minerals, iron and steel, and nonferrous metals industries. Net imports actually decrease for these last three industries when the United States and the developed world set a pricing policy together but the United States unilaterally implements EITE and LDC gratis rebates. The presentation also estimated leakage from production shifts only and found them to be fairly low compared to other studies that include demand effects from changes in fuel prices and the amount of total emissions reductions resulting from the policy.

Another presentation in this session examined a range of carbon pricing and rebate schemes, accounting for the improved macroeconomic performance that can result from recycling revenues from allowance auctions to lower distorting income taxes. These schemes included economywide and sector-based programs, along with alternative allowance distribution mechanisms, including full auctioning and grandfathering without output-based rebates to auctioning or grandfathering with output-based rebates for EITE industries and LDC allocations. Three main conclusions emerged. First, the equilibrium permit price is significantly affected by allowance rebates to the electricity sector, but less so to EITE industries. Second, if the rebates are restricted to EITE industries, then the allocations can improve U.S. welfare compared to 100 percent auctioning, in large part by improving the terms of trade and by reducing leakage. Third, the effectiveness and desirability of LDC allocations depend crucially on the opportunity costs of the allocation to electric utilities. Revenue recycling is generally a more productive use of the allowance values, but if that is not feasible and the allowances would otherwise be grandfathered, output-based allocations in the electricity sector help constrain prices, which also improves real wages (though not as effectively as a tax cut). Overall, the costs of grandfathering are substantial. Output is less affected under auctioning than grandfathering; the average production decline across the different auctioning cases is 0.56 percent compared to 0.89 percent for the grandfathering cases. Interestingly, employment *increases* under the auctioning scenarios presented, as revenue recycling raises the real wage.

The presentation also distinguished between output losses resulting from reduced domestic consumption (representing conservation and switching to less carbon-intensive products) versus that which results from shifts in production abroad (which contributes to leakage). Because output-based allocations offset both kinds of shifts, assessing their desirability involves comparing the conservation opportunities lost to the leakage reduced. The amount of leakage can also be broken down into two components: leakage from shifting production abroad (which can be addressed by allocations) and leakage from lower international prices for fossil fuels that results from lower U.S. demand (which can only be addressed by multilateral climate policy).

The presentation highlighted findings from the modeling work on the leakage rates across industries under the various policy scenarios and by region. With 100 percent auctioning, the average leakage rate for EITE industries is 28 percent. With output-based and LDC allocations, this rate is reduced by more than half. Of course, these average figures mask significant heterogeneity in the leakage rates by industry as well as within these aggregated sectors. On a regional basis, approximately half of the leakage induced by the U.S. policy comes from Annex I countries, with 21 percent from Europe, 12 percent from Canada, and 6 percent from Japan; meanwhile about 20 percent of leakage is attributed to India, Brazil, and China, the countries of greatest concern in the political debate.

Another analysis considered unilateral U.S. action (based on H.R. 2454) on leakage, industry-level profits, and economywide costs using a detailed dynamic model of the U.S. economy that also included preexisting tax distortions and capital dynamics. The analysis emphasized that, for the EITE sectors as a whole, the permit allocations are *overly generous*, resulting in *increases* on average in the net-present value of profits over the period 2009 to 2030. The overgenerous nature of the allocations is even stronger when all permits are given away for free. When permits are allocated via full auctioning, with revenue recycling via tax-rate cuts or lump-sum transfers, the present value of profits declines for all but one EITE industry. The presentation also emphasized that only 30 percent of allowances would be needed (via output-based rebating) or alternatively 22 percent of allowances (via free fixed allocations) to maintain industry profits at base case levels. The amount needed for output-based allocations is larger than that needed for free fixed allocations because of the inefficiency involved in giving out allocations via output-based rebates. By allocating with output-based rebates, EITE industries undertake less abatement; this, in turn, requires more abatement from non-EITE industries to meet emissions reduction targets. Along similar lines, allocations to LDCs discourage demand reductions that would otherwise occur, requiring additional abatement elsewhere in the economy.

Later presentations examined the near-term effects of a carbon tax with output-based rebating and LDC allocations (based on H.R. 2454 proposals), along with the medium and long-term impacts and associated emissions leakage. The near-term impacts were examined based on an input–output framework that considered the short-run impacts of a carbon pricing policy on industry-level costs, profits, and output. The results were presented at the level of 52 industries, of which 33 were manufacturing and 11 were six-digit North American Industry Classification System industries considered "presumptively eligible" for rebates in H.R. 2454. Also highlighted was the significant heterogeneity in electricity and combusted fuel cost shares. Most manufacturing industries have less than a 2 percent share for at least one of these categories, but some industries, including petrochemicals, basic organic chemicals, cement, and aluminum, have considerably higher cost shares arising from either electricity or combusted fuel consumption.

The presentation on near-term impacts highlighted the substantial differences between effects in the very short run (in which industries are assumed to be unable to change their output price) and the short run (in which firms are able to increase output prices), along with the effectiveness of output-based rebating to mitigate them. The short-run output declines in manufacturing industries generally range from 1.5 to 2.5 percent, with the three highest ranging from 4.5 to 6 percent. The allocation provisions in H.R. 2454 tend to mitigate a large proportion of these impacts, with a few industries seeing almost complete mitigation of output and profit declines from the output-based rebating and LDC allocations. One important observation was that the additional flexibility afforded by transitioning from the very short-run to the short-run was just as important, if not more so, than output-based rebating in mitigating adverse impacts. Comparing results across time horizons, the presenter showed that average EITE output declines became less severe as the time period was lengthened. For example, with output-based rebating and LDC allocations, average EITE output declines are –0.86, –0.54, and –0.53 percent in the short-, medium-, and long-run time horizons, respectively. Not surprisingly, climate policy reduces profits across the board in the short-run scenarios. This contrasts with the results from the dynamic model (in which capital can be reallocated across sectors) that showed profits increasing under H.R. 2454.

Climate Policies in Other OECD Countries: Competitiveness, Leakage, and Integration

Several papers were presented covering Japan, Canada, and the European Union. Two papers on Japanese climate policy were presented, one focusing on the near-term impacts and the other developed from a longer-term, multiregional perspective. Both presentations also highlighted similar concerns about the leakage of production and emissions result from a unilateral policy. The analysis on a Canadian carbon pricing policy focused primarily on the incentives for international integration of carbon markets and the impacts that integration would probably have on Canadian and U.S. economic performance. Finally, presentations by European researchers looked at the effects of proposals for the next phase of the E.U. ETS, as well as additional policy options for addressing subglobal climate policies: border adjustments and exemptions for energy-intensive industries.

The short-run analysis of a Japanese carbon pricing policy yielded several conclusions. First, in a hypothetical Japanese carbon pricing policy similar to H.R. 2454, the relative sizes of marginal cost increases are much greater than in the United States, with three industries experiencing cost increases greater than 18 percent and one more than 29 percent. If Japan adopted an output-based rebating approach to compensating EITE industries similar to that outlined in H.R. 2454, the largest net cost increases would be in the range of 5 to 11 percent. Thus, output-based rebating is a particularly important approach to mitigating the short-run impacts of a carbon price in Japan, reducing impacts by 50 to 80 percent below unrebated levels. In another scenario, the authors considered a rebating scheme similar to the E.U. ETS. Under the E.U.-style rebating approach, 122 industries would be eligible for rebates, compared with 23 industries under the mechanism contained in H.R. 2454. At the same time, comparing the two, it was found that the E.U. and U.S. formulae for output-based rebates, when applied to Japan, yield comparable results in terms of the aggregate net cost impacts.

The long-run analysis of the Japanese economy examined the effects of a carbon pricing policy under different allocation methods—such as full auctioning, grandfathering, and output-based rebating—where the rebates were based on an industry's past share of emissions and in another case value added. In terms of economic efficiency, full auctioning was found to be preferable. In terms of preventing leakage from the Japanese economy, output-based rebating for all sectors, where the rebates were tied to historical emissions intensity, was found to be most effective. The three least effective allocation methods for mitigating leakage in a Japanese policy were grandfathering, full auctioning, and value-added output-based rebating (ordered in declining effectiveness). A highly effective alternative is output-based rebating based on historical emissions intensity for the EITE sectors, with an auction for the remaining permits. This latter approach is almost as efficient as the full auctioning scenario and is also effective at mitigating much of the leakage and other adverse impacts on EITE industries.

Although the presentations on the effects of carbon pricing policies in Japan focused mainly on allocation methods and their effectiveness at mitigating a policy's adverse impacts, we see similar but additional concerns in the analysis of Canadian policies. Compared with the other countries examined at the workshop, Canada faces quite limited opportunities for low-cost domestic emissions reductions, largely because the majority of electricity generation in Canada is from hydroelectric and nuclear power. Other factors that limit Canada's opportunities for low-cost emissions reductions are its dispersed population and its cold winters and hot, humid summers. The presentations highlighted the importance to Canada of global trading and/or North American carbon market integration. Without integration, the allowance price for Canada is expected to be *three times larger* than if a Canadian carbon market was linked with that of the United States. A sole Canada–United States approach would result in a gross domestic product (GDP) decline of 1.2 percent versus a decline of 0.5 percent in Canada with a global carbon market, in both cases compared with a 2020 business-as-usual scenario. Additionally, the loss in Canadian welfare of 1 percent under a Canada–United States policy would decline to about –0.4 percent with a global carbon market. At the industry level, comparable patterns are observed.

In Europe, important considerations need to be examined prior to the implementation of the third phase of the E.U. ETS. In particular, with transitional assistance to energy-intensive industries likely to be tied to sectoral baselines, the design and implementation of these baselines is critically important. According to the amended E.U. ETS Directive 10a, "In defining the principles for setting ex-ante benchmarks in individual sectors or sub-sectors, the starting point shall be the average performance of the 10 percent most efficient installations in a sector or sub-sector…in the years 2007–2008."[2] A general principle proposed for benchmarking is that only one benchmark should be established per product group, but this raises questions about how many product groups must be distinguished, what defines product grouping, and whether benchmarks should have any corrections for plant size, age, raw material quality, and other circumstances. The proposal also does not make clear whether the efficiency measured should be carbon dioxide efficiency or some other energy efficiency metric.

Although most presentations considered different allocation regimes in combination with a uniform carbon price, a presentation by researchers from the European Union considered an alternative policy of simply differentiating carbon pricing across sectors. They distinguish between two main motives for a country wanting to treat different industries separately: a terms-of-trade motive and a leakage motive. Under the terms-of-trade ("beggar thy neighbor") motive, differential emissions pricing can serve as a substitute for tariff protection on traded goods. The leakage motive concerns the familiar attempt to counteract the movement of production abroad that can result from pricing carbon. They find that, for the European Union, the terms-of-trade motive would lead to more stringent regulation of energy-intensive sectors because the European Union is a net importer of all fossil fuels; on the other hand, the leakage motive would lead to less stringent regulation of energy-intensive sectors relative to other ones.

Other E.U. researchers compared the post-2012 effects of unilateral versus multilateral action—modeled to include reductions from the European Union (20 percent from 1990 levels), Canada (3 percent), Japan (9 percent), and Russia (10 percent) along with a unilateral Chinese reduction in cement sector emissions—highlighting the potential benefits of carbon market integration for the European Union. In particular, the E.U. cement sector sees lower output declines, whereas welfare is virtually unchanged. Under the integrated approach modeled, the European Union would finance part of the emissions reductions, resulting in a reduction of the adverse welfare impacts in the cement sector. Other modeling of an E.U. carbon pricing policy estimated leakage rates in 2016 for the clinker, steel, and aluminum industries and found them to be 16, 39, and 21 percent, respectively, under a unilateral E.U. policy with full auctioning (reducing emissions to 85.7 percent of 2005 levels by 2016). Similar to other modeling results, output-based rebates were found to be highly effective at reducing leakage to other countries under a unilateral policy.

Border Adjustments: An Effective Policy Tool?

Although the discussion at the workshop focused primarily on the effectiveness and desirability of various forms of output-based rebating in unilateral and multilateral carbon pricing policies, one potential approach to mitigating the leakage effects is via the use of BCAs. Much discussion has surrounded the use of BCAs in developing effective unilateral (or near unilateral) climate policies. In particular, the transition to the use of border adjustments in 2020 is a prominent provision in H.R. 2454. Although questions about the legal and political feasibility of border adjustments remain, it is nonetheless important to examine their effectiveness at mitigating emissions and production leakage. Modeling work presented at the conference was done primarily to examine the effectiveness of BCAs in the European Union.

In the first presentation, several interesting findings emerged. First, a unilateral E.U. carbon pricing policy (reducing emissions by 20 percent in 2020 and 50 percent in 2050) would result in an aggregate leakage rate of around 8.8 percent in 2030. With a border adjustment policy, this aggregate leakage under a unilateral E.U. policy would be decreased dramatically. The effectiveness of a border adjustment in this analysis shows that the policy approach is more effective at mitigating leakage in the unilateral E.U. case than when Annex 1 countries act multilaterally in adopting emissions reductions. In the latter case, the aggregate leakage rate is 5.8 percent in 2030, and BCAs reduce this to around 2.3 percent. The BCAs tend to have a modest effect on the reductions in EITE output compared to a unilateral carbon pricing policy. In the E.U.-only (no BCA) case, EITE output falls 1.5 percent and this drops slightly to a 1.3 percent decline with a BCA. For the Annex 1 multilateral action, the energy-intensive industry output falls 2.15 percent without a BCA and actually *increases* to a 2.23 percent decline with a BCA. In both cases, E.U.-only and Annex 1–only, the implementation of a BCA actually exacerbates the effect of the reduction policy on GDP from 1.03 to 1.14 percent and from 1.12 to 1.19 percent declines, respectively. Examining the sensitivity of the results to the region of analysis, comparable results were found when either the United States or Japan implemented a similar unilateral policy.

The analysis also considered the relative effectiveness of different types of border adjustments. Border measures considered included import adjustments based on direct and indirect emissions, direct emissions only, domestic carbon content, and import adjustments combined with export subsidies. Under these different scenarios, it was found that using domestic carbon content for determining the border adjustment was the *least effective* at reducing leakage because E.U. emissions intensities are estimated to be significantly lower than those of its trading partners. Under this case, the leakage rate is 6 percent, compared with the 8.8 percent leakage rate under a unilateral E.U. policy without any border adjustments. A border adjustment that includes subsidies for exports lowers the leakage rate to about 0.1 percent. The declines in output for energy-intensive industries were similar across all variations except the scenario that included export subsidies along with a BCA. In this latter case, the decline in energy-intensive industry output was –0.87 percent, compared with an average decline of around -1.5 percent under the other scenarios. Welfare effects were similar across all variations, with an average E.U. welfare decline of 1.5 percent across all scenarios.

In addition to the above presentation, a model presented earlier examined the effects of an E.U. carbon pricing policy in 2016 also considered the effectiveness of border adjustments in lowering leakage rates. In some cases, border adjustments can result in *negative leakage* for certain industries (e.g., the aluminum, steel, and electricity sectors). This negative leakage stems from the net effects on imports and exports created by certain forms of border adjustments, resulting in emissions being shifted into the European Union. The magnitude of this emissions increase represented about 5 percent of the E.U. reduction when permits are allocated via auctioning. Additionally, the E.U. analyses found that the various border adjustments all yield very similar carbon prices, whereas the different output-based rebating and full auction scenarios result in a much wider range of carbon prices.

Review of Important Results

Although the results presented at the workshop concerned different countries and different levels of aggregation, several overarching themes were apparent from the presentations.

1. *Allocation choices have important economic consequences*: Grandfathering is generally an inefficient way to allocate permits, whereas full auctioning is generally the most efficient, provided that revenues are used to lower distortionary taxes. However, output-based rebates targeted to EITE industries can improve domestic welfare and reduce leakage. Furthermore, when revenue recycling is not politically feasible, allocating allowances in such a way as to keep electricity and other product prices from rising can be better than grandfathering if the preexisting distortions in the economy are more important than the conservation incentives that would be lost.

2. *Output based-rebates help mitigate short-run adverse impacts*: By incorporating some form of output-based rebating for EITE industries, a large part of the initial shock to profits and output can be mitigated.

3. *Time horizons matter*: The analyses presented at the conference focused on results from modeling efforts considering a comprehensive set of time frames for assessing the effects of carbon pricing policies with output-based rebating and border adjustments. In general, the immediate impacts tend to vary significantly across industries (reflecting differing levels of energy and trade intensities) and the impacts tend to decline in the longer term. For most EITE industries, it was found that output declines in the short run tend to fall once capital can be reallocated within and across industries. The results from a few of the U.S. analyses showed that assumptions about how quickly firms can adjust to new carbon pricing realities will make an important difference in how they are affected. In particular, if firms are able to immediately and costlessly adjust to the existence of a carbon price, then allocations under H.R. 2454 may be overly generous. However, if this adjustment

takes time, then allocations under H.R. 2454 are unlikely to mitigate all of the cost impacts of a carbon price.

4. *Defining leakage consistently is important*: Leakage that results from putting a price on carbon comes in one of two main forms. First, production in energy-intensive industries may shift to other countries that have more lax controls on carbon emissions, resulting in an increase in carbon emissions abroad. Second, in the case of a large country like the United States, a substantial carbon pricing policy will significantly reduce the global demand for oil and other carbon-intensive commodities, resulting in a decline in the world prices of these commodities, and a corresponding increase in the quantity demanded abroad. In most of the models informing this workshop, the leakage from production shifts is generally smaller than that resulting from changes in fuel prices.

5. *Distinguishing the two main types of leakage is necessary to mitigate them effectively*: To prevent the emissions leakage that results from shifts in production, a policy such as output-based rebating or, alternatively, some form of a border adjustment, is needed. Emissions leakage that results from increases in the consumption of carbon-intensive products abroad (because of lower world fuel prices) can only be dealt with in the context of multilateral climate policy implementation.

Ideas for Further Research and Policy Work

After exploring a range of issues surrounding the design of policy measures to combat competitiveness and international emissions leakage concerns, the workshop participants offered suggestions for future research and policy work. Below is a sampling of some of the key issues identified.

1. *Disaggregation, Disaggregation, Disaggregation*: Reflecting the current mantra among politicians for jobs, jobs, jobs, policy analysts place a comparable emphasis on the future importance of industry disaggregation in modeling of the international effects of carbon pricing policies. Because many of the industries that are most vulnerable under a carbon pricing policy are fairly small, at least when compared to the overall size of their respective economies, the adverse impacts they face (in terms of profits, costs, output losses, and emissions leakage) can be blurred when focusing only on more aggregated industry levels. This observation raises two important concerns highlighted by participants. First, from a technical standpoint, how can analysts efficiently disaggregate industries? Second, how much disaggregation is appropriate from a policy perspective? Addressing the first point will require an examination of the existing data for each country to make decisions about the level of disaggregation that can be achieved. As for the second issue, no clear consensus emerged. Although one analyst suggested that the level of disaggregation should match the industry detail of the policy proposal at hand, others saw virtue in going beyond the current proposals.

2. *The Importance of Communicating Results to Policymakers*: Particularly with both domestic and international policies still in flux, several comments emphasized the importance of presenting the results of what are often technical analyses in a more user-friendly form. This sort of packaging will likely prove important in the coming climate policy discussions at both domestic and international levels.

3. *It's All in the (Technological) Details*: Many of the current approaches to modeling climate change policies at the national and international levels require assumptions about the substitutability of certain inputs and technologies in the production process. For example, how easily can firms substitute among coal, oil, and gas, and how responsive are suppliers in those industries? These substitution possibilities are the main current focus, and they require improved empirical estimates. However, in the longer run, firms may also change their mix of other intermediate inputs, including energy-intensive products like steel and chemicals, and renewable energy sources are likely to become a growing share of the energy mix. Although the current assumptions of limited substitution possibilities may be a good approximation for shorter time spans, over longer time frames the existence of a price on carbon is likely to alter the plausible technological mix (and thereby the input–output matrix that forms the basis of many models) in significant ways.

4. *Revenue Recycling*: Inasmuch as the auctioning of emissions permits will result in substantial new sources of government revenue, the issue of revenue recycling has received considerable attention. As is well known, a number of papers have found that significant benefits accrue from using auction revenues to make reductions in existing distortionary taxes. From an economic perspective, individuals should be willing to substitute between an effective tax on the use of carbon-intensive products in exchange for a reduction in another tax (e.g., payroll taxes) that would leave them, on net, better off. The important question then is why hasn't revenue recycling (sometimes known as the *green tax shift*) played a more prominent role in existing climate pricing proposals? Perhaps policymakers do not see climate policy as the correct vehicle for reforming the tax system. If one wanted to reform the tax system, one would do that separately, as one respondent put it. At the same time, participants broadly supported the view that the economics community should continue work in this area, including both research and public discussion of the results.

5. *Is There an Acceptable Amount of Leakage?* Few would maintain that a country is better off without some level of international trade. If one's primary goal is to completely eliminate emissions leakage from a carbon pricing policy, then no international trade is the optimal level of international trade—clearly a nonstarter. The question was raised, is there an optimal level of leakage? If there is an optimal level of leakage, then how do researchers determine what this amount is? Future research into the metric and tools needed to analyze this question in a consistent framework is needed.

6. *Leakage is a Dynamic Problem, so the Models Should Be as Well*: Much of the existing disaggregated climate policy modeling work involves static models. However, it is clear that firms make forecasts about the future, and these forecasts play an important role in decision making. The need for dynamic models is critical. Additionally, participants suggested that researchers should take into consideration real world conditions and go beyond the notion that firms chase every small discrepancy in marginal rates of return. Different institutional structures within different countries will likely play an important role, perhaps through the different expectations they generate about the future implementation of carbon pricing and business conditions.

7. *Sector-Based Polices*: Almost all of the research presented at the conference focused on national emissions reductions (via a cap-and-trade program or a carbon tax) but one possibility that could potentially gain ground in the United States is that of sector-based policies. Indeed, in certain respects the E.U. ETS is a sector-based policy. Important questions surround these policies. In particular, what are the various ways in which a sector-based policy could be approached? How would they be implemented and what would the effects be? How would sector-based policies interact with national emissions reduction goals? How are they likely to stack up in terms of efficiency and cost? If sector-based policies gain ground in the United States, what is the preferred way to model them? Do sector-based policies involve greater or less uncertainty than national ones?

8. *EPA and U.S. Regulation*: Following the *Massachusetts v. EPA* decision, efforts are underway to develop a domestic regulatory structure based on the Clean Air Act. Should researchers devote time to analyzing the effects of command-and-control–based approaches to reducing greenhouse gas emissions? If so, how does one go about modeling such approaches?

9. *Model Solution and Legislative Timelines:* Many of the provisions in H.R. 2454 would phase out over time. However, the static modeling frameworks used in most analyses cannot readily account for such phaseouts. Because static models often incorporate some assumption about capital mobility (and hence have implications about the time horizon they are analyzing), it is important to think seriously about what that means for the level of allocations attributed to particular industries. For example, does a static model without capital mobility best refer to the middle part of H.R. 2454's allocation timeline or does it best depict the end of the period? Arguably, the former interpretation would require the researcher to build in a higher proportion of allocations than the latter.

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1. The term *energy-intensive and trade-exposed* (EITE) *industry* is defined in current U.S. legislation (H.R. 2454) as an industry that satisfies one of the following conditions:

a. having either an energy or greenhouse gas (GHG) intensity greater than 5 percent and a trade intensity greater than 15 percent or
b. having an energy or GHG intensity greater than 20 percent.

Energy, GHG, and trade intensities are defined as follows.

Energy intensity: the sum of expenditures on electricity and fuel consumption divided by the industry's output.

GHG intensity: 20 times the number of tons of carbon dioxide equivalent GHG emissions (including direct emissions, process emissions, and indirect emissions from electricity consumption) divided by the industry's output.

Trade intensity: the total value of an industry's imports and exports divided by the value of that industry's output plus imports.

Note that EITE is generally used to simply describe industries that have a large share of their costs from energy consumption and face significant competition from importers of comparable outputs. Also note that the European Union uses a slightly different definition and that some countries (e.g., Japan) do not have specific definitions. As a result, the use of EITE in this document refers to the general notion, unless mentioned in the context of a specific U.S. or E.U. analysis (in which case the definition is specific to the respective region) or unless otherwise noted.

2. For the full document see:
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0063:0087:en:PDF