Harvard Project on Climate Agreements

The Political Economy of Carbon Pricing Policy Design

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THE HARVARD PROJECT ON CLIMATE AGREEMENTS

The goal of the Harvard Project on Climate Agreements, which was established in 2007, is to identify and advance scientifically sound, economically sensible, and politically pragmatic public policy options for addressing global climate change. Drawing upon leading thinkers from around the world, the Project conducts research on policy architecture, key design elements, and institutional dimensions of international and domestic climate-change policy. The Project is directed by Robert N. Stavins, A. J. Meyer Professor of Energy and Economic Development, Harvard Kennedy School. For more information, see the Project's website: www.hks.harvard.edu/hpca

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THE POLITICAL ECONOMY OF CARBON PRICING POLICY DESIGN

Joseph E. Aldy[1]

I. INTRODUCTION

In 2015, the international community established the goal to limit “the increase in global average temperature to well below 2⁰C above pre-industrial levels.”[2] In light of historic greenhouse-gas emissions and the ambition of mitigation actions pledged under the framework of the Paris Agreement, this is an ambitious goal that will require global emissions to decline eventually to zero or, in some scenarios, even be on net negative through carbon sequestration technologies (Clarke et al. 2014; UNEP 2016). With more than 80% of the world’s energy coming from the combustion of fossil fuels (IEA 2016), achieving this goal will necessitate a dramatic transformation of the energy foundation of the global economy.

To drive reductions in greenhouse-gas emissions, policymakers have employed a vast array of policy instruments: voluntary agreements with industry, subsidies for low- and zero-carbon technologies, product labeling, emission-performance standards, energy-efficiency standards, mandates for low-carbon technology procurement and use, emission cap-and-trade programs, and carbon taxes. Economists have long endorsed the last two of this set — cap-and-trade and carbon taxes — because they can directly price carbon emissions. In doing so, the policymaker can leverage the incentives of businesses and individuals alike to seek out and exploit the lowest cost ways of reducing emissions. Pricing carbon delivers clear signals to innovators and entrepreneurs to develop and market new, low- and zero-carbon technologies and products. Policymakers can apply carbon-pricing policies to a very broad set of sources in an economy, potentially covering all fossil-fuel-carbon emissions under a single policy. In contrast to alternative instruments, carbon pricing can enable emission abatement at lower costs, across all activities associated with the production and consumption of energy; spur more innovation to lower technology costs over time; and maximize the social benefits of climate policy by explicitly aligning the carbon-pricing policy with the benefits of reducing greenhouse-gas emissions (Aldy et al. 2010).

The basic mechanics of carbon-tax and cap-and-trade design are straightforward. The government could set a tax in terms of dollars per ton of carbon dioxide (CO_2) from all sources

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[2] Article 2, Paris Agreement, FCCC/CP/2015/L.9/Rev.1; http://unfccc.int/resource/docs/2015/cop21/eng/10a01.pdf.

covered by the tax.[3] Periodically, these sources would report their emissions and pay the tax liability associated with the emissions. A cap-and-trade system constrains the aggregate emissions of regulated sources by creating a limited number of tradable emission allowances — in sum equal to the overall cap — and requiring those sources to surrender allowances to cover their emissions. Faced with the choice of surrendering an allowance or reducing emissions, firms place a value on the allowance reflecting the cost of the emission reductions that can be avoided by surrendering the allowance. Trading of emission allowances in secondary markets results in a price on carbon. The direct price on CO_2through a tax would create the incentive for firms to find the lowest-cost way to use less of the fuels that emit these emissions during combustion — through fuel switching, energy efficiency investments, and conservation — or by capturing and sequestering the emissions associated with their combustion. Likewise, the allowance prices that emerge under cap and trade drive the use of allowances toward their highest-valued use: covering those emissions that are the most costly to reduce and providing the incentive to undertake the least costly reductions.

In practice, carbon pricing has received increasing attention in real world policy design in recent years. Several northern European countries implemented carbon tax policies starting in the 1990s, and the European Union launched the world's largest CO_2 cap-and-trade program in 2005 (Aldy and Stavins 2012). In North America, the Canadian province of British Columbia set an economy-wide carbon tax in 2008, and the U.S. state of California established a near-economy-wide CO_2 cap-and-trade program in 2012 (Burtraw et al. 2012; Murray and Rivers 2015). In emerging economies, seven provinces and cities in China operated carbon cap-and-trade programs starting in 2013, and Mexico set a carbon tax on fossil fuels in 2014 (Munnings et al. 2014; SEMARNAT 2014). By the end of 2016, about 40 countries and more than 20 cities priced carbon through cap-and-trade and carbon-tax policies (World Bank 2016).

A large economics literature has addressed the question of cap and trade versus tax in climate change and other environmental policy contexts (e.g., Goulder and Parry 2008; Aldy et al. 2010; Aldy and Stavins 2012; Goulder and Schein 2013). In many cases, however, governments' decisions to use carbon pricing policies and their subsequent design has reflected political economy considerations as much as it has the economic principles of pricing a negative externality. Implementing a policy that alters the returns to the production and consumption of energy will create an array of winners and losers among fossil-fuel, renewable, energy-efficiency, manufacturing, and other types of firms. The uncertainties associated with a new

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[3] To maintain simplicity, I focus on carbon dioxide emissions in this paper. It is possible to apply a tax or cap and trade to non-carbon dioxide greenhouse-gas emissions. Implementing a broader scope of gases raises questions about administrative feasibility, including the specification of trading ratios across gases. Likewise, I make references to carbon prices in terms of dollars per metric ton of carbon as a shorthand. Any given government would employ the currency commonly used in its economy in implementing a tax or a cap-and-trade-program auction.

policy and in the design choices of a given policy can influence stakeholder support from the environmental and business communities, as well as affect broader public acceptability. The pre-existing policy landscape — with its regulatory mandates, subsidy regimes, and related programs targeting greenhouse gas emissions, as well as a country's tax- and environmental-policy infrastructure — likewise affects the design and impact of carbon pricing policy.

This paper examines the choice between — and design of — CO_2 cap-and-trade and tax policies through a political-economy lens. It draws from insights in economics and political economy to highlight important public policy principles and policy options in carbon-pricing policy design. The paper illustrates each of these insights with examples from cap-and-trade and tax policy experiences. Revealed political preferences about carbon-pricing-policy design can, in practice, inform our understanding of how decision-makers weigh various policy principles, as well as policy objectives. The balance of the paper examines the following design choices: establishing and phasing-in policy targets; setting the point of compliance and scope of coverage; addressing uncertainties in emission and cost outcomes under carbon pricing; updating carbon-pricing targets over time; using revenue and other forms of economic value created by carbon pricing; mitigating adverse competitiveness impacts of pricing carbon; accounting for the existing, complex policy landscape in designing carbon pricing; and linking of carbon-pricing programs. The final section concludes with a discussion of policy implications and next steps for policy-relevant scholarship.

II. ESTABLISHING AND PHASING IN POLICY TARGETS: TAX RATE AND EMISSIONS CAP

Policymakers may use carbon pricing as a mechanism for implementing an economically efficient policy — one that maximizes net social benefits — or as a means for cost-effectively attaining goals set by a process that reflects more than an accounting of monetized benefits and costs. For example, an economically efficient carbon tax would be set equal to the marginal benefits of emission reduction (which could be approximated by the social cost of carbon; USG [2016]) and would increase over time (Aldy et al. 2010). Likewise, emission caps under a cap-and-trade program could be set such that the expected marginal costs (i.e., allowance prices) would equal the expected marginal benefits of reducing CO_2.

In practice, governments have set their climate-change goals that reflect a broader set of environmental, energy, political, and other economic considerations than represented in a standard benefit-cost analysis. For example, many countries' emission mitigation pledges under the 2015 Paris Agreement would likely result in mitigation efforts and costs that deviate from the expected benefits of emission reductions, at least as measured by the social cost of carbon (Aldy et al. 2016). The mitigation pledges are complicated functions of domestic politics and international relations (Keohane and Victor 2016). The process of translating voluntary national goals to domestic mitigation policies must also go through a political economy process.

Regardless of how the initial carbon-tax rate or emission caps are determined, they will likely need to become more stringent over time. This evolution over time reflects: (1) the need to drive global emissions down to zero in the long-term: (2) the increasing expected damages of incremental CO_2 emissions; and (3) the political challenge of transitioning to a carbon-pricing policy. Just as greater stringency in carbon tax policy translates into tax rates that escalate over time, progressively more stringent emission caps would likely yield increasing allowance prices over time.

The political constraints on the transition into a carbon-pricing policy would likely preclude immediately imposing a carbon price consistent with the long-term policy target. For example, going from a \$0/tCO_2 tax to more than \$40/tCO_2 — approximately the global social cost of carbon (USG 2016) — would be a shock to the energy system and broader economy in any nation and impose transition costs that could be lowered through a phase-in approach (Aldy 2016). Likewise, setting a cap that gradually declines over time would attract greater political support than a dramatic reduction imposed immediately.

In the carbon tax context, British Columbia implemented a carbon tax starting at \$10 (Canadian dollars) per ton of CO_2 and climbing annually until it reached \$30/tCO_2 in 2012. The European Union and China have each experimented with pilot cap-and-trade programs before tightening their emission caps. The EU launched its Emission Trading Scheme in 2005, with a three-year pilot period that ended before the more stringent Kyoto-period targets began in 2008. This pilot phase imposed a relatively lax emission cap to enable time for covered facilities and government regulators to gain experience with the trading regime before moving into a more stringent second phase in 2008. China has experimented with seven regional pilot cap-and-trade programs in major provinces and cities since 2013. Learning from this experience has informed the Government of China's plan to implement a nationwide CO_2 cap-and-trade program (World Bank 2016).

III. POINT OF COMPLIANCE AND SCOPE OF COVERAGE

In the design of either instrument, policymakers must decide on the point of compliance. In the tax context, this would reflect the identification of the taxpayers and the tax base. In the cap-and-trade context, this would be referred to as the regulated entities. In either case, the government could apply the carbon pricing policy "upstream" on fossil fuel suppliers based on the carbon content of fuels; "downstream" on final emitters at the point of combustion; or it could employ a hybrid of the two. In an upstream approach, refineries and importers would pay a tax based on the carbon content of their gasoline, diesel fuel, or heating oil; coal mine operators would pay a tax reflecting the carbon content of extracted coal; and natural gas companies would pay a tax reflecting the carbon content of their produced and imported gas. The design of the British Columbia carbon tax is upstream in this sense (Murray and Rivers 2015).

Such an upstream approach is, administratively, relatively simple and feasible, consistent with standard public-finance tax principles. For example, focusing on the carbon content of fuels would cover about 98 percent of U.S. CO_2 emissions, through a relatively small number of firms — two to three thousand — as opposed to the hundreds of millions of smokestacks and tailpipes that emit CO_2 after fossil fuel combustion. Given the molecular properties of fossil fuels and the lack of commercially viable capture or scrubbing technology, monitoring the physical quantities of fuels consumed yields a precise estimate of the emissions they release during combustion. Thus, a tax could incorporate existing methods for fuel-supply monitoring and reporting to the government authorities and could be piggybacked on existing excise taxes. For example, U.S. petroleum refineries and petroleum product importers already pay a tax per barrel of crude oil refined to finance the oil spill liability trust fund and coal mines already pay a tax per ton of coal mined to finance the black lung disability trust fund (Aldy 2016). It would be easy to apply the accounting of these existing taxes for either carbon-tax or cap-and-trade compliance purposes.

A downstream point of regulation or taxation would assign compliance responsibilities to the final emitters. The EU Emission Trading Scheme takes this approach, with large manufacturing facilities and power plants responsible for holding allowances to cover their CO_2 emissions. Given the administrative challenges of extending such a downstream approach to small emitters — vehicles, buildings, etc. — it may be easier to employ an upstream system to cover a broader base (i.e., a larger fraction of an economy's emissions). Alternatively, a hybrid upstream-downstream approach could address a broad base, such as in a system that covers power plants' direct emissions and transportation's embedded emissions, with refineries serving as the point of compliance for petroleum fuels. For example, California's cap-and-trade program employs this kind of hybrid approach (California EPA 2015).

IV. ADDRESSING UNCERTAINTIES IN CARBON PRICING

In a world without uncertainty, a carbon-tax and a cap-and-trade program could be designed and implemented to yield identical carbon prices and emission reductions. But the choice of policy instrument can affect the carbon price, emissions, and the net social benefits of the climate policy program, given the real-world *uncertainty* that characterizes emission mitigation (Weitzman 1974; Pizer 2002; Aldy and Viscusi 2014). The government must implement a climate policy before uncertainty about the cost of emission mitigation can be resolved. If mitigation costs are higher than the government expected, then the climate policy will yield either (a) fewer emission reductions (if the government implemented a carbon tax); or (b) higher costs (if the government implemented cap and trade). By delivering fewer emission reductions than expected, the tax produces lower-than-expected economic benefits from mitigating climate change. By requiring emission reductions with high mitigation costs, the cap-and-trade program produces higher-than-expected economic costs. If this increase in economic costs under cap and trade exceeds the reduction in benefits under the carbon tax, then a tax would, on social welfare grounds and under conditions of uncertainty, be the preferred policy instrument. Otherwise, cap and trade would likely maximize net social benefits relative to a carbon tax (Pizer 2002).

Uncertainty about the price of carbon inhibits private-sector investment. In recent years, uncertainty about the type, design, and stringency of climate policy has adversely affected new-energy and climate-related technology investment. Uncertainty about future modifications to a climate policy may also deter investment, especially in long-lived energy-related capital. For example, a future government could relax policy stringency (with a lower carbon tax or higher emission cap) that would lower the economic return to low- and zero-carbon technology investments. Alternatively, under a cap-and-trade regime, a future government could wipe out the value of an emission allowance bank (the allowances set aside and banked for future use), by changing the rules for using banked allowances or layering over additional policies that reduce the effective stringency of the cap-and-trade program, not unlike recent experience with the effect of regulatory changes on the U.S. SO_2 cap-and-trade program (Chan et al. 2012).

A stable policy and regulatory framework can mitigate some of these concerns and reassure stakeholders, especially those with business interests impacted by the carbon pricing policy. For example, the decade-plus experiences with the ETS in the European Union and the carbon tax in British Columbia have enhanced the predictability of policy that stakeholders seek. The enduring policy regimes reflect in part the efforts of policymakers to adapt to new information in modifying the carbon pricing in ways that square with stakeholders' expectations.

While the business community would prefer cost certainty, the environmental community favors certainty about greenhouse-gas-emission levels. The former European Commission President Jose Barroso (2007) expressed this preference when stating: "Why is it important that we talk about cap-and-trade schemes? First and foremost, they provide environmental certainty" (emphasis in original). The Natural Resources Defense Council (2009), a leading U.S. environmental advocacy group, likewise stated that "a cap would also provide greater environmental certainty for reducing emissions than a tax." Placing much greater weight on emission reductions reflects the concern of some in the environmental community that business will simply "buy its way out" under a carbon tax and fail to undertake emission mitigation, even though it may be in businesses' interests to do so.

In an emission-trading program, cost uncertainty — unexpectedly high or volatile allowance prices — can undermine political support for climate policy and discourage investment in new technologies and R&D. To promote the political feasibility of cap-and-trade systems, attention has turned to incorporating the "cost containment" measures of allowance banking and borrowing, safety valves, and price collars.

Allowance banking and borrowing effectively permits emission trading across time. The flexibility to save an allowance for future use (banking) or to bring a future period allowance forward for current use (borrowing) promotes cost-effective abatement and effectively redefines a series of annual emission caps as a cap on cumulative emissions over a period of years (Aldy et al. 2010; Fell et al. 2012). The EU has permitted banking of emission allowances since the beginning of its Kyoto phase in 2008.

A safety valve puts an upper bound on the costs that firms will incur to meet an emission cap by offering regulated entities the option of purchasing additional allowances from the government at a predetermined price. This effective price ceiling reflects a hybrid approach: a cap-and-trade system that transitions to a tax in the presence of unexpectedly high mitigation costs. When firms exercise a safety valve, their aggregate emissions exceed the emission cap. The State of California has implemented a variant of a safety valve through its "allowance price containment reserve" (California EPA 2015). In effect, the state withholds a small fraction of allowances from auctions and makes them available for purchase through a quarterly auction at a set price (which exceeded $\$50/tCO_2$ in 2017; Air Resources Board 2017).

A price collar combines the ceiling of a safety valve with a price floor created, for example, by a reserve price in allowance auctions. Both the California cap-and-trade program and the Regional Greenhouse Gas Initiative (RGGI), a power-sector-only system among nine states in the northeastern Unites States, have employed reserve prices in their allowance auctions. The price floor has been binding for most RGGI auctions, with the cap-and-trade auction reserve price serving as a de facto carbon tax. Since 2013, the United Kingdom has implemented a carbon price floor — effectively a carbon tax intended to make up the difference between the EU ETS allowance price and a carbon price target set by the UK government (Ares and Delebarre 2016). Price collars represents a hybrid approach to carbon pricing. If the carbon price under cap and trade moves too low or too high, then the price floor or safety valve kicks in and the instrument effectively transforms into a tax.[4]

V. UPDATING CARBON PRICING

The vast majority of emission-mitigation pledges made under the 2015 Paris Agreement focus on emission-quantity goals of one form or another. Designing a carbon tax to implement a given mitigation pledge may raise questions about the likelihood of delivering on the pledge. In theory, a country could implement an economy-wide cap-and-trade program in which the cap equals the emission goal in that country's NDC. In practice, however, no country has done this. The timing and limited scope of cap-and-trade programs also raise questions about how national mitigation pledges through 2030 map to the setting of these programs' emis-

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[4] A number of U.S. states have also employed such a hybrid framework in their renewable portfolio standards, which mandate a quantity of power from qualifying renewable sources subject to a price cap.

sion caps. Moreover, many of the uncertainties that influence the political economy of carbon pricing motivate both the design of flexible implementation — as described in the previous section — as well as adaptability of carbon pricing policies to new information.

The carbon-pricing policy could be designed with explicit and automatic rules that adjust the stringency of the policy in response to new information. Given environmentalists' concerns about whether a carbon tax will deliver necessary emission reductions, future tax rates could be set conditional on achieving emissions goals (Metcalf 2009; Hafstead et al. 2017). For example, the Swiss Carbon Tax Law employs such a rules-based approach (Hafstead et al. 2017).[5] The government designed the carbon tax to increase over time, but also conditioned the amount of increase on whether emission benchmarks had been met by specific milestones. For example, the carbon tax began at 12 Swiss francs per metric ton of CO_2 in 2008 and increased to 36 CHF by 2012. The Swiss government increased the carbon tax for 2016 to 84 CHF, and it is scheduled to increase again to 96 CHF effective January 2018, because emissions exceeded the interim benchmarks set by the government.[6] Triggering automatic adjustments to the carbon tax, based on its impact on quantitative emission outcomes, mirrors a price collar on a cap-and-trade system, effectively changing the tax into more of a quantity-based instrument.

Alternatively, policymakers could pursue a discretionary approach to updating carbon pricing. In contrast to rules that automatically adjust the tax rate, this discretionary approach may require new legislation, regulations, and/or multi-government agreements on new emission caps or tax rates. For example, the northeast U.S. states have agreed to more ambitious emission caps under RGGI in response to lower power demand and natural gas prices, which have kept actual emissions below RGGI's initial emission caps (RGGI 2012). California and the European Union have each moved forward with efforts that set lower post-2020 emission caps. These discretionary approaches will reflect both the evolution of political constituencies' influence as well as the nature of institutions through which changes are made.

A discretionary approach could also be formalized through a structured process. For example, Aldy (2017b) proposes such a process for a U.S. carbon tax. Under this "structured discretion" approach, every five years the president would recommend an adjustment to the carbon tax based on analyses by the Environmental Protection Agency, the Department of the Treasury, and the Department of State on the environmental, economic, and diplomatic dimensions of climate policy. Similar to the expedited, streamlined consideration of trade deals under trade promotion authority, Congress would vote up or down on the presidential recommendation for a carbon tax adjustment, without the prospect of filibuster or amendment. This process

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[5] For details on the Swiss tax law, refer to: www.admin.ch/opc/en/classified-compilation/20091310/index.html.

[6] Refer to the Federal Office for the Environment webpage on the CO_2 levy: www.bafu.admin.ch/bafu/en/home/topics/climate/info-specialists/climate-policy/co2-levy/imposition-of-the-co2-levy-on-thermal-fuels.html.

could be synchronized with the updating of nationally determined contributions under the Paris Agreement to leverage greater emissions mitigation ambition by other countries in future pledging rounds. The communication of guiding information and the latest data and analysis could serve as "forward guidance" for carbon tax adjustments, akin to the Federal Reserve Board's communication strategy.

VI. USE OF REVENUES AND ALLOWANCE VALUE

Carbon-pricing policies have distributional impacts that can profoundly affect the political feasibility of a climate policy and therefore choice among climate-policy instruments. These impacts are transmitted through increases in energy prices (differentially across fuels, geographical regions, sectors, income-level groups) and the allocation of carbon-pricing-program revenues. Management of distributional impact, in the carbon tax context, involves decisions about the use of carbon tax revenues. In the cap-and-trade context, it involves how emission allowances are initially distributed.

Allowances could be allocated for free, reflecting some historical record, such as recent fossil fuel sales (so-called "grandfathering"). Grandfathering involves a transfer of wealth, equal to the value of the allowances, to existing firms, whereas an auction transfers the same level of wealth to the government. Grandfathering of allowances could enhance the political feasibility of a cap-and-trade policy, by securing the support of many of the firms responsible for demonstrating compliance with the emissions program (Schmalensee and Stavins 2017). The EU ETS began with nearly universal allowance grandfathering, but has since evolved toward an increasing role of allowance auctions.

Alternatively, governments could auction allowances and collect revenue identical to that from a tax that produced the same level of emissions. In any case in which the government receives an increase in revenues, it would need to explore options for using the revenues, such as cutting existing taxes, paying down the debt, financing research and development, or subsidizing favored technologies or industries.

When Sweden implemented its carbon tax in 1991, it was part of a tax swap. Thus, the government raised revenues by taxing carbon and reduced revenues through lower marginal tax rates on income (Aldy and Stavins 2012). British Columbia returns all of the carbon tax revenues either through lower tax rates on personal and business income, or a means-tested transfer program to address concerns about the regressivity of pricing carbon (Murray and Rivers 2015).

In contrast, the RGGI states and the state of California have primarily used their allowance-auction revenues to finance energy efficiency, clean energy, and other climate-related investments (Schmalensee and Stavins 2017). This reflects both the political economy of policy design — investors in the clean energy space have supported RGGI in part because of this funding stream — as well as idiosyncratic institutional constraints. In California, focusing monies on climate-related projects only requires a simple majority of the state legislature to vote for the authorizing legislation. In contrast, if California used allowance revenues to lower income tax rates, it would require a supermajority of the legislature.[7] Similar institutional constraints in the European Union have also contributed to the choice of implementing a cap-and-trade program (which requires a supermajority of the member states) over a carbon tax (which requires unanimity).

The use of revenues during the phase-in of the carbon pricing policy could also make the recycling of the revenues back to households more salient, thereby drawing greater political support. For example, in the month before carbon tax collection began in 2008, the government of British Columbia distributed checks to households representing the revenue expected to be raised by the tax in the first year. This program design addressed the phase-in with regard to both policy stringency and redistribution.

VII. MITIGATING COMPETITIVENESS RISKS

Policymakers may need to design a carbon-pricing policy in a manner that can mitigate the potentially adverse *competitiveness impacts* of the program. The implementation of a carbon tax or cap-and-trade system will increase the cost of consuming energy and could adversely affect the competitiveness of energy-intensive industries (Aldy 2017c). This competitiveness effect can result in negative economic and environmental outcomes: firms may relocate facilities to countries without meaningful climate-change policies, thereby increasing emissions in these new locations and offsetting some of the environmental benefits of the policy.

One approach would be to limit the scope of the policy by exempting firms that may face competitiveness pressures. Some of the carbon-tax policies implemented in northern Europe, starting in the 1990s, either exempted trade-exposed manufacturing industries or gave them opportunities for opting out. For example, Denmark discounted carbon tax rates by as much as 90% for manufacturing firms that participated in a voluntary emission agreement with the government (Aldy and Stavins 2012). Sweden has imposed a high carbon tax (exceeding $100/tCO_2$), but exempted refineries, steel, and other primary metal industries (Aldy and Stavins 2012).

Another approach would target some of the economic value created under the carbon-pricing policy to potentially affected manufacturing firms. Under a carbon tax, revenues could be returned to these firms through an output-based tax credit (Gray and Metcalf 2017). Under

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[7] The original authorizing legislation for California's cap-and-trade program, Assembly Bill 32 — the California Global Warming Solutions Act of 2006 — passed with a simple majority. This legislation was reauthorized in 2017 when the state legislature passed Assembly Bill 398 with a supermajority.

cap and trade, free allowances could be directed toward these firms, also as a function of their output (Fischer and Fox 2012). The European Union has employed this latter approach in the Emission Trading Scheme.[8] The European Commission identifies the most vulnerable industries and estimates a benchmark emissions rate per unit of output by industry. This benchmark is then used to allocate additional allowances, free of charge, to firms in these industries as a function of their output.

Finally, a country could impose a border-tax adjustment on the carbon content of goods imported into its country. In theory, this could ensure that domestically-produced goods under a carbon pricing policy would face a level playing field relative to goods produced by competitors operating in countries without carbon pricing. In practice, this raises a host of issues about administrative complexity, compliance with international trade agreements (bilateral as well as under the World Trade Organization), and the risks this poses to future multilateral coordination on climate policy (Aldy 2017c). While no country has implemented a border tax adjustment to date, this issue plays a role in policy debates — for example in the U.S. debate over cap-and-trade policy in 2009 and 2010.[9]

VIII. ACCOUNTING FOR COMPLEX POLICY LANDSCAPES AND OVERLAPPING POLICY INSTRUMENTS

Although public policies are frequently proposed and analyzed in isolation, they in fact interact with one another in a number of important ways, which can affect a policy's environmental effectiveness and costs. Policies of all kinds — both market-based instruments and conventional policies — act as implicit taxes and interact with existing taxes in ways that drive up the policies' costs — the so-called tax-interaction effect (Goulder 1995). These interactions can significantly influence the costs of a climate policy (Goulder and Parry 2008). Carbon-pricing instruments that produce revenues for government can dedicate part or all of their revenue to cutting existing, distortionary taxes, thereby offsetting some or (in principle) all of the tax-interaction effect.

The interaction of flexible, quantity-based policies, such as cap-and-trade programs, with other climate policies introduces an additional set of issues (McGuinness and Ellerman 2008; Goulder and Stavins 2011; Levinson 2011). To illustrate this, consider the two firms that each participate in a CO_2 cap-and-trade program, but the first firm is also subject to a regulatory mandate to install solar power capacity. If the regulatory mandate is binding — i.e., if it results in the first firm investing in more solar than it would have been economic to do if it operated only under the cap-and-trade program — then this firm would reduce emissions more than it would under the cap-and-trade program. As it reduces its emissions, the

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[8] For details of the EU approach, refer to: https://ec.europa.eu/clima/policies/ets/allowances/leakage_en.

[9] The American Clean Energy and Security Act of 2009 (H.R. 2454, 111th Congress), which passed the U.S. House of Representatives, included a border adjustment mechanism calibrated to the price of allowances in the cap-and-trade program.

first firm now has lower demand for emission allowances and will try to sell unused emission allowances into the market, which would depress allowance prices. The second firm will find it economic to buy these unused allowances from the first firm instead of undertaking more costly emission abatement. As a result, the second firm's emissions are higher and exactly offset the first firm's emission reductions. So long as the emission cap in the cap-and-trade program is binding, layering regulatory mandates over the trading scheme will only shift the emission reduction activities but not change the aggregate level of emissions.

Lower carbon prices weaken incentives for innovation and deployment of mitigation technologies that are not favored by the additional policies, and can spur policy remedies such as the UK carbon price floor (Ares and Delebarre 2016). The additional regulation will increase marginal abatement costs for relevant sources or sectors, making the overall flexible (cap-and-trade) regime no longer cost effective and, among other things, possibly making it more difficult (politically) to increase stringency over time.

These are major issues for cap-and-trade programs, as well as non-carbon pricing policies, such as renewable electricity standards, clean energy standards, and motor-vehicle fuel efficiency standards. Problematic interactions can occur when one policy instrument is nested within another, as with subnational and national policies, or when two policy instruments coexist within the same political jurisdiction. *Some of these issues are potentially less severe with a carbon tax* than with quantity-based policies, because the multiple policies could yield a lower emission level than the carbon tax in isolation. However, these benefits would still come at the expense of cost-effectiveness.

The problem of overlapping policy instruments is common to virtually every effort to employ carbon pricing in the developed world. The EU Emission Trading Scheme covers power plants, which also operate under member-state policies governing renewable power subsidies and energy-efficiency mandates. The California cap-and-trade program applies to the power sector, in addition to the state's solar subsides and renewable power mandates. Likewise, refineries in California operate under both a low-carbon fuel standard and the CO_2 cap-and-trade program. In RGGI, electric utilities operate under the regional CO_2 cap-and-trade program, as well as under renewable portfolio standards implemented by individual states.

Public officials face a strong incentive to identify and select policies and instruments with minimal *perceived* costs. The costs of a pricing system are relatively transparent, while those of a command-and-control policy are more opaque (though the economic cost of the latter will generally be higher for a given environmental outcome). Layering over command-and-control regulations and/or subsidies may hide or partially obscure the costs of carbon pricing. Largely for this reason, ordinary performance and technology standards have long been favored over market-based instruments in the developed world (Keohane et al. 1998). A prime example is the apparent political attraction of Corporate Average Fuel Economy standards as a means of increasing the fuel efficiency of American automobiles, in contrast with the political aversion to gasoline taxes, even though the latter would accomplish more at lower cost (but in a highly visible manner) (Jacobsen 2013).

IX. LINKING CARBON PRICING POLICIES

Linkage among carbon pricing regimes can reduce compliance costs and improve market liquidity, in the context of cap-and-trade, and deliver comparable abatement incentives among the countries linking their programs. There has been considerable interest in linking cap-and-trade systems with each other, as well as with emission offset programs like the Kyoto Protocol's Clean Development Mechanism (Jaffe et al. 2010). A parallel issue arises with respect to national or subnational carbon taxes: namely, they can be linked in productive ways. For purposes of overall cost effectiveness, the various taxes would need to be set at the same level, that is, harmonized (Cooper 2010). The prospect of harmonization is complicated by equity issues — would developing countries harmonize taxes without some form of side payments? — and related tax issues: how might carbon tax harmonization account for preexisting energy subsidies in developing countries and high preexisting energy taxes in some developed countries?

Considering the variety of policy instruments — both market-based and conventional command-and-control — that countries can employ to reduce their greenhouse gas emissions, it is important to ask whether a diverse set of heterogeneous national, subnational, or regional climate policy instruments can be linked in productive ways. The answer is "yes" in some cases, although coordinating a set of more homogeneous cap-and-trade systems would be easier (Metcalf and Weisbach 2011; Mehling et al. 2017). The linking to date, such as between California and Quebec in their cap-and-trade programs, reflects the focus on connecting relatively more homogenous policies. The emergence of linked cap-and-trade programs may reflect the suitability of establishing links between cap-and-trade systems, the explicit actions among program designers to align their programs to facilitate linking, and the greater salience of coordinating efforts for trade-based regimes than for coordinating tax regimes.

The one exception lies in the experience with emission offsets. An offset provision allows taxpayers or regulated entities to offset some of their emissions with credits from emission-reduction measures outside the cap-and-trade system's scope of coverage. For example, emissions associated with land-use change fall beyond the scope of current cap-and-trade and carbon tax policies, but projects that reduce these emissions could generate offsets. In addition, a crediting system for downstream sequestration — such as capturing CO_2 at a coal-fired power plant and storing it underground — could complement an upstream carbon-pricing policy. These offsets could take the form of tax credits under a carbon tax or allowance-equivalent credits under cap-and-trade. Mexico provides tax credits for offset activities under its carbon tax (SEMARNAT 2014), while the EU ETS allowed firms to use offsets from Clean

Development Mechanism projects for compliance during the Kyoto phase of the program. The Mexican provision further illustrates the hybridization of carbon pricing, with certified emission reductions from an offset project — typically associated with cap-and-trade programs — playing a role in carbon tax compliance.

Carbon prices could serve as focal points that could facilitate opportunities for linking two or more programs under a variety of situations (Aldy 2017b). First, consider governments that have an interest in linking their programs with other governments' programs that have similar carbon prices. These governments may prefer to avoid large resource transfers and the creation of large winners and losers through linking. Instead, the linking serves to create liquidity and price stability across the linked programs. Two countries sharing this interest and employing a carbon-price focal point could then move forward with linking while also coordinating the design of key elements of their programs, such as price collars and non-compliance fines, based on the focal point. Second, governments may identify opportunities to link with programs with different expected carbon prices, because this could signal large gains from trade. Linkage in these cases may also create de facto side payments that could encourage more substantial participation by potential laggards. A carbon price focal point, such as the social cost of carbon, could serve as a guide for welfare-improving links. If linked programs deliver a carbon price that is closer to the SCC than the price each unlinked market would deliver, then the linking increases social welfare.

X. CONCLUSIONS

This paper has reviewed a variety of design issues that play an important role in the political acceptability and the long-term durability of carbon-pricing policies. Different countries have pursued different avenues in the choice of pricing instrument and its design. These choices will influence the cost-effectiveness, environmental performance, and distributional outcomes of carbon pricing in practice. Given the long-term risks posed by climate change and the long lifetimes of carbon-polluting capital, a successful climate change policy will need to be politically durable (Carlson and Fri 2013). The design of carbon pricing policy in practice reveals political preferences over key elements of these programs, subject to important institutional constraints idiosyncratic to each governing jurisdiction (Burtraw 2013).

This paper has gleaned insights from carbon pricing policy in practice, which by design means that it focuses on policies that have survived the initial political vetting in their respective jurisdictions. It is important to recognize that political support for carbon pricing is not automatic or permanent, as evident by failed efforts to pass legislation to authorize a CO_2 cap-and-trade program in the U.S. Congress in 2009–2010, as well as the reversal of carbon pricing policy in Australia in 2014. A durable climate policy has sufficient, initial public support to be enacted and can continue even as the original political coalition promoting the policy no longer exists. Structuring carbon pricing to be flexible in response to various market and technology shocks and to be adaptable to new information is critical to ensuring policy durability as political stakeholders evolve in their support and role in policy debates (Burtraw and Carlson 2017). Table 1 synthesizes the discussion of the design elements in this paper to show how they reveal governments' approaches to securing stakeholder support in launching carbon pricing policies as well as in designing a flexible and adaptable framework to ensure its durability.

As Table 1 illustrates, some provisions of carbon pricing are chosen in a way to elicit the initial support for launching the domestic climate policy program. Other elements are intended to address longer-term issues associated with carbon pricing implementation and to ensure that the carbon pricing framework is resilient and durable in the presence of new, political, economic, and technological risks. As additional governments consider carbon pricing as a key tool in implementing their climate policy agendas, the choices over these design elements — reflecting their own domestic political considerations and institutional constraints — can influence the durability and success of their climate policy programs.

Table 1. Political Revealed Preference and the Design of Carbon Pricing

Design Element	**Role in Political Durability**
Phasing in Policy Targets	The use of pilot phases and less stringent initial tax rates and emission caps can ensure that the transition to carbon pricing does not impose politically unpalatable economic costs. After demonstrating the political viability of the carbon pricing regime, the stringency of policy targets can ramp up over time.
Point of Compliance	Selecting the point of compliance to ensure a broad scope of coverage reduces the administrative complexity of carbon pricing and ensures that greater emission reductions are achieved at lower economic cost and administrative-compliance burden.
Addressing Uncertainty	Hybrid instruments — such as safety valves and price collars in cap-and-trade and tax triggers based on emission benchmarks — can provide flexibility in implementation that can mitigate concerns of various stakeholders about the uncertainties and associated risks characterizing carbon pricing.
Updating Carbon Pricing	Formally designing the updating of carbon pricing over time can ensure that the policy adapts to new information on the economic, environmental, and political dimensions of the climate problem.
Use of Revenues and Allowance Value	The substantial economic value created by carbon pricing can be allocated in ways to secure support from key stakeholders at the start of a carbon-pricing policy. Over time, these revenues could target other interests — such as in lowering income tax rates — in a way that can broaden the political coalition of support.
Mitigating Competitiveness Risks	Tailoring the carbon-pricing policy to mitigate the competitiveness risks to energy-intensive manufacturing can broaden support for the policy among businesses and labor groups. Doing so can also deliver the flexibility of implementation that can respond effectively to changes in other countries' carbon pricing policies.
Overlapping Policy Instruments	Layering energy and climate policies on top of carbon pricing may lower the transparent costs of the carbon pricing regime — but at the expense of higher total costs — and provide additional incentives for businesses favored by these overlapping instruments. Continuing these policies may be the political cost of securing sufficient support to initiate carbon pricing.
Linking Carbon Pricing Policies	Linking of carbon pricing policies provides additional flexibility in policy implementation and can further buffer domestic programs against economic and other shocks.

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