
Harvard Project on Climate Agreements

Carbon Taxes vs. Cap and Trade: Theory and Practice

Robert N. Stavins

Harvard Kennedy School

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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. For more information, see the Harvard Project's website: www.hks.harvard.edu/hpca.

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CARBON TAXES VS. CAP AND TRADE: THEORY AND PRACTICE

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ABSTRACT

There is widespread agreement among economists – and a diverse set of other policy analysts – that, at least in the long run, an economy-wide carbon-pricing system will be an essential element of any national policy that can achieve meaningful reductions of CO₂ emissions cost-effectively in the United States and many other countries. There is less agreement, however, among economists and others in the policy community regarding the choice of specific carbon-pricing policy instrument, with some supporting carbon taxes and others favoring cap-and-trade mechanisms. How do the two major approaches to carbon pricing compare on relevant dimensions, including but not limited to efficiency, cost-effectiveness, and distributional equity? This paper addresses this question by drawing on theories of policy instrument choice pertaining to the attributes – or merits – of the instruments. The paper also draws on relevant empirical evidence. It concludes with a look at the path ahead.

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This paper compares the two major approaches to carbon pricing – carbon taxes and cap and trade – in the context of a possible future climate policy, and does so by treating both instruments in a balanced manner, examining their merits and challenges without necessarily favoring one or the other. I focus on the United States, though I draw upon experience in Canada, Europe, and South America. I try to follow the principle that when making comparisons of policy instruments based on their attributes – or merits – it is most valuable to compare either idealized versions of the instruments or realistic (likely to be implemented) versions of both, thereby avoiding a comparison of an idealized version of one instrument with a less-than-ideal, but realistic version of another (Hahn and Stavins 1992).

In the next section, Part I, I describe the key premises I adopt, and in Part II, I examine theoretical dimensions of policy instrument choice based on the merits of the instruments. I include brief reviews of the major options and pay particular attention to what theory suggests about the choice between price and quantity instruments for abating carbon dioxide (CO₂) emissions. In Part III, I examine empirical evidence: that is, what experience can tell us with regard to empirical evidence bearing on the merits, including lessons learned from experience with taxes and cap and trade. In Part IV, I offer some conclusions and comment on the path ahead.

1. MAJOR PREMISES OF THE ANALYSIS

Gradually, over the 25 years since the U.S. Senate ratified the United Nations Framework Convention on Climate Change, scientific assessments of the risk of global climate change have become increasingly compelling (Intergovernmental Panel on Climate Change 2013, 2018), and economic analyses supporting the wisdom of policy action have gained consider-

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able prominence, if not influence (Nordhaus 2015).² While China's annual emissions have surpassed those of the United States since 2006, the United States remains the largest contributor to the accumulated atmospheric stock of anthropogenic greenhouse gases (GHGs) (Boden, Marland, and Andres 2017).

Countries around the world – including nearly all of the industrialized countries and large emerging economies – have launched or are in the process of launching national policies aimed at reducing their emissions of GHGs. Of the 169 Parties to the Paris climate agreement that have submitted specific pledges (known as “Nationally Determined Contributions” or NDCs), more than half (88 to be exact) refer to the use of carbon pricing in their NDCs. To date, some 51 carbon-pricing policies have been implemented or are scheduled for implementation worldwide, including 26 carbon taxes and 25 emissions trading systems (Table 1).³

Together, these carbon-pricing initiatives will cover about 20% of global GHG emissions (World Bank Group 2019), and many of these systems may eventually be linked with one another under the auspices of Article 6 of the Paris Agreement (United Nations 2015; Bodansky *et al.* 2015; Mehling, Metcalf, and Stavins 2018). In the midst of these global and national developments, the current U.S. administration stands out for its rejection of the science of climate change, its decision to withdraw from the Paris Agreement, and its comprehensive moves to reverse climate policy initiatives of the previous administration.

There is widespread agreement among economists – and a diverse set of other policy analysts – that, at least in the long term, economy-wide carbon pricing will be an essential element⁴ of any policy that can achieve meaningful reductions of CO₂ emissions cost-effectively in the United States, as well as in many other countries, including in South America (Metcalf 2009;

2 The phrase, “wisdom of policy action,” refers to the global dynamic efficiency of cost-effective actions taken to reduce global emissions, without suggesting that the direct climate change benefits to a single country – in particular, the United States – would exceed the costs it incurs through unilateral actions (that is, without being part of effective international cooperation). However, if domestic co-benefits of U.S. climate policies are taken into account, such as the health impacts of reductions in fine particulates due to decreased coal combustion, then a unilateral U.S. climate policy can be welfare improving for the United States (Stavins 2014).

3 Most of the emissions trading systems are cap and trade, but one very important one is a tradable performance standard: namely China's system, which was officially launched in December 2017 and is likely to be implemented in 2020.

4 Carbon pricing may be necessary but it would not be sufficient, because other market failures limit the impacts of price signals (Jaffe, Newell, and Stavins 2005). One example is the well-known principal-agent problem that constrains incentives for energy-efficiency investments by either landlords or tenants in renter-occupied properties. Another is the public-good nature of research and development, whereby firms capture only a share of the benefits of the information their research produces. Both types of market failure argue for specific policies that would complement a carbon-pricing regime (Stavins 2010).

Kaplow 2010; Borenstein *et al.* 2018).⁵ The ubiquitous nature of energy generation and use and the diversity of CO₂ sources in a modern economy mean that conventional technology and performance standards would be infeasible and, in any event, excessively costly (Newell and Stavins 2003). The cost advantage of carbon pricing exists because of the flexibility pricing provides and the incentive it fosters for all sources to control at the same marginal abatement cost, thereby achieving cost-effectiveness in aggregate. In addition, in the long term, pricing approaches can reduce abatement costs further by inducing carbon-friendly technological change (Newell, Jaffe, and Stavins 1999).⁶

There is less agreement among economists regarding the choice of specific carbon-pricing policy instruments, with some supporting carbon taxes (Mankiw 2006; Nordhaus 2007) and others cap-and-trade mechanisms (Ellerman, Joskow, and Harrison 2003; Keohane 2009). That prompts the question: How do the two major approaches to carbon pricing compare on relevant dimensions, including but not limited to efficiency, cost-effectiveness,⁷ and distributional equity?

Among many findings from this survey and synthesis, one major conclusion stands out: The specific designs of carbon taxes and cap-and-trade systems may be more consequential than the choice between the two instruments. These two approaches to carbon pricing are perfectly or nearly equivalent in regard to some issues and attributes, while significantly different in regard to some others. But many of these differences fade with specific implementation choices, as elements of design foster greater symmetry. Indeed, what appears at first to be a dichotomous choice between two distinct policy instruments often turns out to be a choice of design elements along a policy continuum.

5 There is a prominent minority view that because sufficiently high carbon prices are politically unattainable, the only politically feasible path is making carbon-free energy cheaper (not making carbon-intensive energy more costly). The thinking from private-industry representatives in the renewables sector tends to be that government subsidies are the answer, while the response from some policy analysts is that government-funded research initiatives should be the prime focus (Stepp and Trembath 2013; Sachs 2018). Others recognize that carbon pricing may be the first-best policy for the long term, but argue that the best set of approaches for the short term may be those that are politically achievable (Gillis 2018; Goulder 2019b).

6 Two additional advantages of carbon-pricing instruments are that they encourage demand-side conservation and can raise revenues for governments, which, through judicious use of those revenues, can lower the social costs of the policies (Goulder and Hafstead 2018; Metcalf 2019).

7 A “cost-effective” policy is one that achieves a particular environmental objective (for example, a 10% reduction in emissions within a particular jurisdiction) at the lowest cost, as compared with alternative policy instruments. An “efficient” instrument is one that has the greatest net benefits (benefits minus costs).

2. THEORY OF POLICY INSTRUMENT CHOICE: ATTRIBUTES OF ALTERNATIVE POLICY INSTRUMENTS

For much of the past 100 years, economists have considered environmental pollution to be a classic – indeed, textbook – example of a negative externality: an unintentional consequence of production or consumption that reduces another agent’s profits or utility (Pigou 1920). A separate but related strand of literature, stemming from Ronald Coase’s work (1960), has identified environmental pollution essentially as a public-good problem – that is, a problem of incomplete property rights. These two perspectives can lead to different policy prescriptions for climate change: carbon taxes versus tradable carbon rights.⁸

For some 40 years prior to Coase (1960), the literature focused on a single economic response to the problem of externalities: taxing the externality in question. In principle, a regulator could ensure that emitters would internalize the damages they caused by charging a tax on each unit of pollution, equal to the marginal social damages at the efficient level of pollution control (Pigou 1920). Such a system makes it worthwhile for firms to reduce emissions to the point where their marginal abatement costs are equal to the common tax rate. Hence, marginal abatement costs will be equalized across sources, satisfying the necessary condition for cost-effectiveness. In theory, this will hold both in the short term and in the long term, by providing incentives for the diffusion (Jaffe and Stavins 1995) and innovation (Newell, Jaffe, and Stavins 1999) of low-cost abatement technologies.

Following Coase (1960), it became possible to think about solving the problem of pollution as one of clarifying poorly defined property rights. If resources such as clean air and water could be recognized as a form of property, whose corresponding rights could be traded in a market, private actors could allocate the use of this property in a cost-effective way. Some 50 years ago, Thomas D. Crocker (1966) and J. H. Dales (1968) each proposed a system of transferable discharge permits that could provide such a market solution: the regulator need only designate the total quantity of emissions allowed (the cap), distribute rights corresponding to this total, and allow individual sources of emissions to trade the permits until an optimal allocation had been reached. This was the fundamental thinking behind what has come to be known as “cap and trade.”⁹

Under this approach, an allowable overall level of pollution is established by the government (not necessarily at the efficient level), and allocated among firms in the form of tradable allowances. Firms that keep their emissions below their allotted level may sell their surplus allowances to other firms or use them to offset excess emissions in other parts of their operations.

8 Both the Pigouvian (externality) and Coasian (property rights) approaches are examples of missing markets (Arrow 1969).

9 Cap-and-trade systems should not be confused with emission-reduction-credit or offset systems, whereby permits are assigned when a source reduces emissions below some baseline, which may or may not be readily observable (Stavins 2003).

Under these conditions, it is in the interest of each source to carry out abatement up to the point where its marginal control costs are equal to the market-determined price of tradable allowances. Hence, the environmental constraint is satisfied and marginal abatement costs are equalized across sources, satisfying the condition for cost-effectiveness.¹⁰

Although the two instruments – carbon taxes and carbon cap and trade – may be said to derive respectively from the externality (Pigou 1920) and property-rights (Coase 1960) perspectives, the two approaches are more similar than different. A carbon tax would directly place a price on carbon (most likely upstream, where fossil fuels – coal, petroleum, and natural gas – enter the economy), with quantities of carbon use and CO₂ emissions adjusting in response. An upstream carbon cap-and-trade system would constrain the quantity of carbon entering the economy through allowances on the carbon content of the three fossil fuels, with prices emerging indirectly from the market for allowances.

In some cases, what may at first appear to be key differences between the two instruments fade on closer inspection, while other apparent differences survive such inspection. I first explore symmetries between carbon taxes and cap and trade, and then I turn to significant differences.

2.1 Equivalence, Similarities, and Symmetries

To a significant degree, a carbon tax and a commensurate cap-and-trade system are functionally similar, with differences in specific design elements dominating fundamental differences between the instruments themselves (Stavins 1997; Goulder and Schein 2013). I examine six areas of symmetry: (1) emissions reductions, (2) abatement costs, (3) possibilities for raising revenue, (4) costs to regulated firms (with respective revenue-raising instruments), (5) distributional impacts, and (6) competitiveness effects. The findings that emerge in regards to these six areas are summarized in Table 2, where I characterize the symmetries between carbon taxes and cap and trade as being perfectly equivalent, nearly equivalent, or similar.

2.1.1 Emission Reductions

In the absence of uncertainty, by setting the respective time-paths of the tax rate or the emissions cap, commensurate tax and trading instruments can achieve the same emissions reductions. Both instruments can employ an upstream, midstream, or downstream point of regulation (distinct from the point of allocation of allowances). This does not affect aggregate cost in either case, but it can affect decisions about the scope of coverage, and therefore can affect environmental effectiveness as well as cost-effectiveness. With either carbon tax or cap-

¹⁰ In theory, as I discuss later, a number of factors can adversely affect the performance of a cap-and-trade system, including: concentration in the permit market (Hahn 1984); concentration in the related product market (Malueg 1990); transaction costs (Stavins 1995); non-profit-maximizing behavior, such as sales or staff maximization (Tschirhart 1984); the preexisting regulatory environment (Bohi and Burtraw 1992); and the degree of monitoring and enforcement (Montero 2007). Some of these factors also affect the performance of pollution taxes.

and-trade, focusing on the carbon content of fossil fuels upstream could enable a policy to capture up to 98% of U.S. CO₂ emissions with a relatively small number of compliance entities – on the order of a few thousand – as opposed to the hundreds of millions of smokestacks, tailpipes, and other sources that emit CO₂ as a by-product of fossil-fuel combustion (Metcalf 2007; Stavins 2007).

2.1.2 Abatement Costs

If firms subject to a policy are operating in a competitive market, they have strong incentives with either pricing instrument to minimize their total costs, which include the sum of abatement costs and tax liability, or the sum of abatement costs and cost of allowance purchases (or net of allowance sales revenue).¹¹ In both cases, there is an incentive to abate emissions up to the point where each source's marginal abatement cost is equal to the tax rate or the market-determined allowance price. Hence, all firms control at the same marginal cost, and so the same (minimized) aggregate cost is experienced across the scope of the policy.

Considering the temporal dimension of the respective policies, an important question is the relative effect of the two approaches on technological innovation. Here, a series of theoretical explorations have found that a tax and a cap-and-trade system (with auctioned allowances¹²) are equivalent in their incentives for carbon-saving innovation (Milliman and Prince 1989; Jung, Krutilla, and Boyd 1996), or at least that neither system dominates (Fischer, Parry, and Pizer 2003).¹³

Finally, in principle, offsets for emissions reductions outside the respective programs can be used with either tax or trading regimes, bringing about additional abatement cost savings (Goulder and Schein 2013).

2.1.3 Possibilities for Raising Revenue

An important attribute of a carbon tax is that it raises revenue for the government, which can be used for a variety of beneficial public purposes, including (but not limited to) using the revenue to enable cuts in the rates of distortionary taxes and thereby lowering the net social cost of the overall policy (Bovenberg and Goulder 1996). (“Distortionary” taxes, on income

11 Whether firms receive allowances for free (sometimes called grandfathering) in a cap-and-trade system or via auction, they face the same marginal opportunity cost for emissions.

12 Throughout this paper, I frequently include the caveat of considering cap-and-trade systems that include auctioning of allowances, because it is with this design that the symmetry of these price and quantity instruments is greatest.

13 A related temporal issue is that carbon prices – and, for that matter, performance standards – that devalue existing carbon-intensive capital can have the effect of fostering stranded assets (Rozenberg, Vogt-Shilb, and Hallegatte 2019), which could create political resistance to policies. The problem of stranded assets can be avoided with policies that target only new investments, as opposed to the existing capital stock, but this would introduce the problems created by vintage-differentiated regulation (Stavins 2006).

and capital, impose costs on the economy by creating disincentives for work and investment.) More broadly, given the need for government revenues for other purposes as well, the ability to raise revenue is indeed an important attribute of taxes.

Of course, an auction mechanism in a cap-and-trade system can, in principle, accomplish the same outcome (Goulder and Schein 2013). In this regard, of various cap-and-trade designs, it has been estimated that auctioning and recycling revenue via income tax cuts would have the least social cost, while the most costly approach would be to recycle revenue through lump-sum dividends or freely-allocated allowances (Parry and Williams 2010). The results are similar for the use of revenue from a tax.

Since the systems are theoretically equivalent in their ability to raise revenue, any differences in this regard would be in terms of implementation. One possible difference is that given the committee jurisdictions in the U.S. Congress, it could be more difficult to link revenue recycling with a cap-and-trade system than it would be to link revenue recycling with a carbon tax (Metcalf 2007). This is because, in the cap-and-trade case, committees with environmental jurisdiction *and* committees with financial jurisdiction would need to be involved in the legislative process, whereas for a revenue-neutral carbon tax only the financial committees would be necessary. Whether or not this causal chain is the real explanation, there is empirical support for the overall point from global experience, where about 70% of cap-and-trade auction revenue has been earmarked for green spending, while 72% of carbon tax revenue has been recycled or dedicated to general funds (Carl and Fedor 2016).

2.1.4 Costs to Regulated Firms (with Revenue-Raising Instruments)

The cost of a carbon tax or cap-and-trade system that includes auctioning greatly depends on the use of the revenue. Compared with a lump-sum redistribution of revenue (rebates), recycling through rate cuts in payroll taxes, individual income taxes, or corporate income taxes may have net costs (after accounting for the benefits of eliminating the excess burden of distortionary taxes) that are 15%, 26%, and 67% lower, respectively (Goulder and Hafstead 2018).¹⁴

The results for a cap-and-trade system with complete auctioning of allowances are similar. With a lump-sum rebate, the cost is identical to the rebate paired with a carbon tax. According to one set of estimates, if auction revenue is recycled via cuts in tax rates, then there are “slight differences” in costs, compared with respective cuts in the same tax rates (above) with a carbon tax (Goulder and Hafstead 2018). If allowances are not auctioned, but instead are given out for free, then the costs are considerably greater than with auctioning: at best, 8%

¹⁴ All of the numerical estimates in the Goulder and Hafstead paper are from analyses carried out prior to implementation of the “Tax Cuts and Jobs Act” of 2017. One effect of that set of tax reforms would be to lessen the magnitude of the efficiency gains that could be achieved from further cuts in corporate tax rates (Metcalf 2019).

higher than if lump-sum rebates are employed and 200% higher than if revenue was recycled through corporate tax rate cuts (Goulder and Haftstead 2018).

If the comparison is between a cap-and-trade system with freely allocated allowances and an ordinary carbon tax, then the cost differential is significant. In fact, free allocation could increase the regulatory costs of carbon cap and trade enough that the sign of the efficiency impact could conceivably be reversed from positive to negative net benefits (Parry, Williams, and Goulder 1999). On the other hand, as I discuss below, free allocation of allowances would meet with much less political resistance.

It might appear that cap-and-trade systems offer greater opportunities to protect the profits of regulated firms (through free allocation of allowances), but, as I discuss below, the same can be accomplished under a tax regime through inframarginal tax exemptions for emissions below a specified level.

2.1.5 Distributional Impacts

In principle, either instrument can be designed to be roughly equivalent to the other in distributional terms. If allowances are auctioned, a cap-and-trade system looks much like a carbon tax from the perspective of regulated firms. Likewise, if a carbon tax system includes tradable tax exemptions¹⁵ for a specified quantity of emissions (that is, the tax is levied only on emissions above a specified amount), then a carbon tax can resemble a cap-and-trade system with freely allocated allowances (Goulder and Schein 2013). This is because inframarginal tax exemptions have the same effect as freely allocated allowances in a cap-and-trade system: they allow a specified quantity of emissions for which a compliance entity need not pay.

Goulder and Haftstead (2018) and others have examined minimum free allocations that could make firms whole in terms of fully compensating them for their compliance costs. In general, these minimum free allocations turn out to be a relatively small share of allowances, yet they produce significant reductions in overall costs (with auctioning and recycling of the remainder of allowances). In theory, a similar approach is conceivable with a carbon tax system: namely, tradable exemptions to the carbon tax for emissions up to some threshold where the tax begins (Goulder and Hafstead 2018).

Household distributional impacts also can be identical, depending upon two elements of design: the extent of free emissions and the use of revenue. This result emerges from an assessment of two components of household impacts of a carbon price. One component has been termed “use-side impacts,” reflecting how a policy affects the relative prices of goods and services purchased by households – in other words, impacts that take place through household *expenditures*. The other component has been termed “source-side impacts,” reflecting how the

15 A compliance entity that receives more exemptions than needed may sell the exemptions to other entities.

policy affects nominal wages, capital, and transfers – in other words, impacts that take place through household *income* (Goulder and Hafstead 2018; Goulder *et al.* 2018; Metcalf 2018, 2019). On the use side, carbon pricing is generally regressive (ignoring the return of tax revenue), due to changes in the prices of goods and services. Although the degree of regressivity can be altered by the use of the revenue, this effect remains regressive (Goulder and Hafstead 2018).¹⁶

However, on the source side, changes in wage and capital income (as well as government transfers) are generally progressive.¹⁷ Lump-sum recycling of the revenue makes this very progressive. Using the revenue instead for cuts in corporate tax rates, the effect is still progressive, although somewhat less so. Most importantly, in most cases (in the models employed by Goulder and Hafstead (2018) and others), the overall (use-side plus source-side) impact tends to be progressive. Because source-side impacts dominate use-side impacts for most cases where there is revenue recycling (rate cuts in payroll or individual income taxes), the overall impact of carbon taxes – or cap and trade with 100% auctioning of allowances and the same recycling through tax-rate cuts – is progressive. Using the tax or auction revenue for lump-sum rebates is even more progressive. Hence, there is a tradeoff: namely, that by using approaches that are more cost-effective (tax-rate cuts), the progressivity is less than it is with lump-sum rebates (which are most progressive, but most costly because distortionary taxes are unaffected).

2.1.6 Competitiveness Effects

A frequently expressed concern about new proposals for carbon-pricing policies is their impact on competitiveness. The concern is that by increasing the costs of producing carbon-intensive goods and services within a jurisdiction, there will be a shift in comparative advantage to the production of those same goods and services in other jurisdictions that do not face commensurate climate-policy compliance costs. In theory, this can produce “leakage” of economic activity and of related emissions.

In reality, such leakage may be relatively modest, particularly if the emissions occur in non-traded sectors, such as electricity generation, transportation, and residential buildings, but energy-intensive manufacturing industries could face incentives to relocate. Additional emissions leakage may occur through international energy markets: As countries with climate policies reduce their consumption of fossil fuels and drive down fuel prices, those countries without such policies may increase their fuel consumption in response to the lower prices (Aldy and Stavins 2012).

16 This discussion abstracts from the fact that there can be a mix of winners and losers in any group, which is missed by focusing on averages.

17 This reflects the fact that carbon-intensive industries (which, of course, face the greatest burden from a carbon tax) tend to be relatively capital-intensive. As a result, the burden of a carbon tax falls more on capital than on labor, and hence tends to reduce returns to capital more than returns to labor. Since capital income represents a larger share of total income for wealthier households than for poorer households, the impacts from reduced returns to capital are progressive.

These impacts on competitiveness would be anticipated equally with either type of carbon-pricing policy instrument (and with virtually any meaningful CO₂-limiting policy, for that matter). The impacts on energy-intensive manufacturing can be mitigated – in theory – through specific elements of policy design with either instrument. With a carbon tax, border adjustments – a tax on imports of products from countries without commensurate climate policies – can be employed. With a cap-and-trade system, an allowance requirement can be employed for those same imports, together with an output-based, updating allocation of allowances (Goulder and Schein 2013), although leakage through international energy markets may remain.

2.2 Differences and Distinctions

In theory, there are also some significant differences and distinctions between the two main approaches to carbon pricing. I examine nine such areas: (1) performance in the presence of uncertainty about benefits and costs, (2) price volatility, (3) interactions with complementary policies, (4) potential market manipulation, (5) transaction costs, (6) macroeconomic implications, (7) ease of linkage with policies in other jurisdictions, (8) complexity and administration, and (9) political resistance to the simplest forms of both instruments.¹⁸ The findings that emerge in regards to these areas are summarized in Table 2, where I characterize the comparison between carbon taxes and cap and trade as representing significant differences, differences, or some distinctions.

2.2.1 Uncertainty About Benefits and Costs

Significant uncertainty characterizes the benefits and the costs of environmental protection. For two decades following Weitzman's (1974) classic paper, "Prices vs. Quantities," it was generally acknowledged that benefit uncertainty on its own has no effect on which policy instrument is efficient, but that cost uncertainty could have significant effects, depending upon the relative slopes of the marginal benefit (damage) and marginal cost functions.¹⁹ In particular, in the presence of cost uncertainty when (the absolute value of) the marginal cost function exceeds that of the marginal benefit function, then – in expected value terms – a price instrument, such as a tax, is likely to be more efficient (smaller social losses due to resource misallocation arising from mistaken predictions of future costs) than a quantity

18 An additional difference, noted by Goulder and Schein (2013), is the potential for wealth transfers to oil exporting nations (that have market power) if those countries choose to behave strategically in response to the imposition of a cap-and-trade system in the United States, with the result that policy-generated rents can be transferred in part from the domestic economy to the oil-exporting countries. In theory, the same phenomenon would not arise in response to the imposition of a U.S. carbon tax.

19 Weitzman's (1974) model assumed uncertainty regarding the level (intercept), but not the slope of the marginal abatement cost function, and assumed no correlation between benefit uncertainty and cost uncertainty. Also, the original analysis considered a situation where the regulator makes a one-time choice of instrument. Subsequent work (discussed below), relaxed these assumptions.

instrument, such as a cap-and-trade system. When the opposite is the case – that is, the slope of the marginal benefit function exceeds the slope of the marginal cost function – then a cap-and-trade instrument would be more efficient.²⁰

In the Weitzman (1974) analysis, benefit uncertainty has no effect on the relative efficiency of the two instruments. However, 20 years after Weitzman's work, it was noted that when there is simultaneous and correlated uncertainty about marginal benefits and marginal costs, and marginal benefits are positively correlated with marginal costs, then it is more likely than it is solely on the basis of the usual, relative-slopes analysis to favor the relative efficiency of the quantity instrument – that is, cap and trade (Stavins 1996). The opposite result holds if there is negative correlation between benefit and cost uncertainty.²¹

It was to be another two decades (Karp and Traeger 2018) before any use was made in the climate-policy context of the findings from Stavins (1996), which drew on an important insight in Weitzman's original analysis. Much sooner than that, however, Newell and Pizer (2003) and others (Hoel and Karp 2002) applied the Weitzman analysis to the circumstances of climate change. Newell and Pizer reasoned that because GHGs accumulate in the atmosphere (with CO₂ remaining in the atmosphere in excess of 100 years), changes in emissions in a specific period of time do not significantly alter atmospheric concentrations. Furthermore, climate change is itself a stock externality – that is, climate change is a function of the amount of GHGs in the atmosphere, not of emissions at any particular point in time.

Newell and Pizer (2003) and others found that this implies that the marginal damage function (for any period) is relatively flat, which means that the marginal benefit function (of emissions reductions for that period) is also relatively flat, whereas the costs of emissions reductions are a function of contemporaneous policies. Hence, the current-period marginal benefits would have a smaller slope (in absolute value) than current-period marginal costs. In this case, the standard Weitzman analysis would suggest that the more efficient climate policy instrument

20 The intuition for this result is that a steep marginal benefit function suggests large gains or losses in the benefits of abatement with relatively small changes in abatement levels. A tax fixes the emissions price, but allows the quantity of emissions to vary, whereas a quantity instrument fixes the emissions (abatement) level and allows the price to vary. Hence, the quantity instrument is favored when the marginal benefit function is steeper than the marginal cost function. On the other hand, a steep marginal cost function suggests that large increases in the costs of abatement take place with relatively small changes in abatement levels. Hence, a price instrument is favored.

21 The intuition for this result is that if emission taxes are used to control pollutant emissions, firms will respond to unexpectedly high marginal control costs by reducing their control efforts. But if there is a positive correlation between uncertain benefits and uncertain costs, then at the same time that firms are reducing their control efforts, the marginal benefits of those efforts will be unexpectedly great. Hence, firms' natural response to an emissions tax will be less appropriate than indicated by the simple relative-slopes rule. On the other hand, if there is a negative correlation between the marginal benefits and marginal costs of control, then unexpectedly high marginal control costs will be associated with unexpectedly low marginal benefits, meaning that a tax instrument will lead firms to reduce their control efforts (because of high control costs) at times at which the marginal benefits of those efforts are unusually low; hence, the tax instrument will lead to particularly appropriate actions.

under conditions of uncertainty about abatement costs will be a price instrument, such as a carbon tax, rather than a quantity instrument, such as cap-and-trade.²²

The above comparison refers to the relative slopes of marginal benefits and marginal costs in a given time period, but the marginal damages of a unit of emissions during some time period (such as the current period) are equivalent to the present discounted value of the future stream of marginal damages, otherwise known as the social cost of carbon (Interagency Working Group on Social Cost of Carbon 2016; Weitzman 2014, 2017). In other words, with a stock pollutant, the marginal benefit of reducing emissions in the current period equals the present discounted value of the stream of reductions of current and future marginal damages. This is the appropriate comparison in the climate change context (Pizer and Prest 2019).

In a recent analysis, Karp and Traeger (2018) utilize this comparison of the slopes of the current marginal cost of CO₂ emissions reduction and the marginal benefits (avoided social cost of carbon) of a current unit of CO₂ emissions reduction. They do this by applying to climate change policy the earlier analysis of the relative efficiency of price and quantity instruments in the presence of simultaneous and correlated benefit and cost uncertainty (Stavins 1996). Karp and Traeger note that an important source of uncertainty is technological change, which brings about a positive correlation between the uncertainty of abatement costs and the uncertainty of (stock-related) damages, because technological change lowers current abatement costs, as well as future abatement costs, due to the persistence of the technology effect. Then, in their closed-loop (feedback) model, future policy makers will take these lower costs into account, reduce future targeted emissions, and lower the expected future pollution stock in the atmosphere.

Hence, today's marginal damage function shifts downward because the damages of emissions now are the discounted present value of the future stream of damages. On this basis, Karp and Traeger find a positive correlation between uncertain benefits and uncertain costs. And, as previously demonstrated (Stavins 1996), such a positive correlation tends to favor a quantity instrument, compared with the finding from the usual relative-slopes comparison, which only considers cost uncertainty and ignores correlated benefit and cost uncertainty.

²² At about the same time the paper by Newell and Pizer (2003) appeared, Hoel and Karp (2002) independently came to the same conclusion regarding stock externalities, but with a different analytical model. In their framework, the ranking of price versus quantity instruments also depends upon the discount rate and the rate of decay of the stock, with higher discount and decay rates favoring price instruments. Hoel and Karp examined both an open-loop policy (as did Newell and Pizer), where price and quantity are set by the regulator and do not change, and a closed-loop (feedback) policy, where price and quantity can be adjusted over time by the regulatory authority in response to new information. In the latter case, the relative efficiency of the two instruments also depends on the length of intervals between adjustments of prices and quantities by the regulator. They parameterized their models to examine the control of GHGs, and found – like Newell and Pizer (2003) – that prices (carbon taxes) are preferred to quantity instruments (cap and trade). See also Hoel and Karp (2001).

This analysis does not lead to an unambiguous finding favoring either the quantity or the price instrument. Rather, the implication of the analysis by Karp and Traeger (2018) is that what was thought to be an unambiguous result from the stock externality application (Newell and Pizer 2003) of the Weitzman (1974) relative-slopes rule becomes ambiguous – that is, it becomes an empirical question of the magnitude of the effect from Stavins (1996), compared with the basic effect of the relative slopes (Weitzman 1974; Hoel and Karp 2002; Newell and Pizer 2003), where the slopes compare current marginal costs with current marginal damages measured as the avoided social cost of carbon. The simple ranking of price over quantity instruments for the stock externality of climate change no longer holds.²³

Karp and Traeger (2018) calibrate their dynamic model, drawing largely on the DICE model (Nordhaus 2015), and find that, in many cases, the quantity instrument is superior to the price instrument. At a minimum, their analysis suggests that quantity instruments can be (but are not necessarily) superior on efficiency grounds to price instruments for addressing climate change. In summary, the case for carbon taxes compared with cap and trade in the presence of uncertainty “is much weaker than commonly believed” (Karp and Traeger 2018).²⁴

2.2.2 Carbon Price Volatility

Putting aside the issue of long-term benefit and cost uncertainty, another issue is short-term price volatility. It is straightforward that the tax approach eliminates the potential for short-term price volatility, which can surely exist under a cap-and-trade system.²⁵ Greater certainty about mitigation cost via a carbon tax (or a price collar in a cap-and-trade system; see below) reduces certainty about the quantity of emissions allowed (Aldy and Stavins 2012).

Such cost uncertainty (price volatility) in a cap-and-trade system can be an impediment to capital investment (Pindyck 2017; Metcalf 2019) and could undermine political support for climate policy and discourage investment in new technologies, as well as in research and development (Aldy and Stavins 2012). From an economic perspective, it makes sense to allow emissions (of a stock pollutant) to vary from year to year with economic conditions that affect aggregate abatement costs. This happens automatically with a carbon tax, but with a cap-and-trade system, such temporal flexibility needs to be built in through provisions for

23 In a distinct, but related analysis, Pizer and Prest (2019) find that with policy updating (closed-loop model), if firms have expectations regarding future policy updates and if the quantity instrument is tradable over time, then the quantity instrument *can* be preferred on efficiency grounds to the price instrument. However, their “main finding” is that the comparative advantage of one instrument versus the other depends more on firms’ information and expectations about policy updates than on the relative slopes of marginal benefits and marginal costs.

24 Given the very recent vintage of the analysis by Karp and Traeger (2018), I have placed this issue – performance in the presence of benefit and cost uncertainty – within the section on differences rather than the previous section on similarities.

25 This is essentially an issue of two different types of endogeneity. Whereas prices are endogenous (and hence subject to fluctuation and volatility) under a cap-and-trade mechanism, emissions are endogenous under a carbon tax (Goulder and Schein 2013).

banking and borrowing of allowances, which redefine the cap as a limit on cumulative emissions over a period of years, rather than a limit on annual emissions (Aldy and Stavins 2012). Conversely, a carbon tax can employ measures to automatically adjust to meet some quantity target (Hafstead, Metcalf, and Williams 2017; Metcalf 2019), as I consider below when examining hybrid policy instruments.

2.2.3 Interactions with Complementary Policies

It is rarely, if ever, the case that carbon pricing instruments are considered as the sole policy to be used to address climate change. More often, carbon pricing – whether carbon tax or cap and trade – is considered as one of a suite of policy measures, such as renewable portfolio standards affecting electricity generation, low-carbon fuel standards affecting refineries, and energy-efficiency policies affecting end users. In fact, if there are other market failures present, such as the principal-agent problem that affects decisions regarding the adoption of thermal insulation in renter-occupied buildings or the public-good nature of information produced by carbon-friendly research and development activities, then there are solid economic arguments in favor of complementing a carbon-pricing regime with other regulatory policies (Schmalensee and Stavins 2017a). But if such additional market failures are not present (and if the complementary policies are not targeting sources outside the scope of the carbon-pricing regime), then differences emerge between carbon taxes and cap and trade.

With a cap-and-trade regime, there are two possibilities of concern. One is that a complementary regulatory policy targets sources under the cap of the cap-and-trade system. The other is that a policy (of any type) is geographically nested within the area of a cap-and-trade system. In either of these situations, the results are threefold (Schmalensee and Stavins 2017a): (1) if the complementary policy is binding,²⁶ there is no additional reduction in emissions due to the complementary policy, but rather a relocation of emissions to other sectors under the overall cap (100% leakage between policy regimes)²⁷; (2) with the binding complementary policy, marginal abatement costs are no longer equalized across all sources, and so aggregate abatement costs are greater than without the additional policy; and (3) allowance prices are suppressed, raising concerns about the ability of the cap-and-trade system to encourage technological change (except in the sector directly regulated by the complementary policy). Hence, under these circumstances, the addition of a “complementary” policy increases abatement costs and lowers allowance prices, but does not – on net – reduce emissions (Goulder and Stavins 2011).

When a carbon tax is paired with complementary policies, the emissions-leakage effect (and allowance price suppression) does not occur, and the complementary policy will serve to reduce emissions below the level that the tax alone would achieve. However, the combination

²⁶ And hence the more restrictive policy, resulting in emissions reductions.

²⁷ Unless the complementary policy renders the allowance price floor binding.

of carbon tax and complementary policy is, as in the cap-and-trade case, not cost-effective, since marginal abatement costs are no longer identical for all sources. It would cost less to abandon the complementary policies, and rely instead on a boosted carbon tax rate to achieve the same degree of aggregate emissions reduction.

2.2.4 Corruption and Market Manipulation

With any policy there is a possibility of corruption of various kinds, including attempts by private firms to manipulate the market. For this reason, cap-and-trade systems require regulatory oversight. In the large European Union Emissions Trading System for GHG control, there was a single and quite significant case of allowance theft in 2011 in the Czech Republic, as well as hacking of allowance accounts in a number of other countries (Metcalf 2019).

The parallel concern with a carbon tax system would presumably be tax evasion of one kind or another, a significant problem in many countries, but not of sufficient magnitude in the United States to present a major concern for a carbon tax (Metcalf 2019). However, much the same can be said of concerns about market manipulation in cap-and-trade systems within this country, since there has been only a single case of fraudulent activity reported (in the RECLAIM program²⁸), which was successfully prosecuted by the U.S. Department of Justice. In the large and ambitious California cap-and-trade system and the electricity-sector system in the Northeast (Schmalensee and Stavins 2017a), there have been no reported cases of attempted fraud. That said, it is difficult to contest the judgment of one analyst that, in the United States, “the risk of cybertheft from electronic registries in a cap and trade system is likely to present a greater problem than the risk of tax evasion in a carbon tax” (Metcalf 2019, p. 82).

2.2.5 Transaction Costs

A cap-and-trade system involves the trading of allowances among firms – therefore, there is the possibility of transaction costs, which increase aggregate compliance costs. More important, if transaction costs take the form of volume discounts, then with such decreasing marginal transaction costs, the equilibrium allocation through market activity is no longer independent of the initial allocation, removing a key political attraction of cap-and-trade (Stavins 1995). But historically, transaction costs – of any form – have not been empirically significant in implemented systems (Schmalensee and Stavins 2017a). Perhaps most significantly, the U.S. sulfur dioxide (SO₂) allowance trading system begun in 1995 demonstrated that, in properly designed systems, private markets can render transaction costs minimal (Schmalensee and Stavins 2013).

28 RECLAIM, for “Regional Clean Air Incentives Market,” is a cap-and-trade system in southern California intended to reduce emissions of certain local air pollutants.

2.2.6 Macroeconomic Factors

In a broader, economy-wide (macroeconomic) context, a number of additional differences may emerge. First, in the presence of economic growth (most simply, in the form of more and/or larger sources of emissions – particularly relevant in some developing countries), a fixed supply of allowances under a cap-and-trade regime means that demand for allowances will increase, allowance prices will rise (reflecting higher marginal abatement costs), but emissions will remain unchanged. A corollary of this observation is the fact that cap and trade is a counter-cyclical policy instrument. When an economy goes into recession, the demand for, and price of, allowances falls – reflecting lower abatement costs – but emissions again are largely unchanged in aggregate (as long as the cap remains binding). In contrast to this, under a carbon tax, during a recession, when emissions have fallen, compliance entities will continue to be taxed on all residual emissions.

General price inflation (also particularly important in some developing countries) will result in higher nominal allowance prices in a cap-and-trade system, but constant real prices, and no change in aggregate emissions or even the distribution of emissions among sources. With a unit tax (not an *ad valorem* tax), expressed as dollars per ton of emissions, for example, the real tax rate falls with general price inflation and so pollution levels will increase.

Finally, exogenous technological change has different consequences in the context of the two pricing instruments. In the case of cap and trade, balanced technological change reduces marginal abatement costs, so allowance prices fall but aggregate emissions are unchanged. In contrast, with a tax approach, such technological change (that reduces marginal abatement costs) results in an increase in control levels – that is, a decrease in aggregate emissions.

2.2.7 Ease of Linkage with Policies in Other Jurisdictions

Linkage of policies across jurisdictions – that is, connections among policy systems that allow emission reduction efforts to be redistributed across systems – is of great potential value because it: (1) can facilitate cost savings by allowing firms to take advantage of lower-cost abatement opportunities in other jurisdictions; (2) may improve the functioning of individual markets by reducing market power by enlarging the trading market, and reducing total price volatility by thickening markets; (3) can provide political benefits to linking parties by conveying a sign of momentum as political jurisdictions band together; (4) provides administrative economies of scale; and (5) allows for distributional equity among nations under existing international climate agreements (United Nations 2015) without sacrificing cost-effectiveness (Bodansky *et al.* 2015; Mehling, Metcalf, and Stavins 2018).²⁹

²⁹ Also, in the international domain, Weitzman (2014, 2017) has argued that negotiating a specific, single carbon price (if nations have already agreed to hold such a negotiation and abide by the negotiated price, where each country has one vote and accepts majority rule) is easier than negotiating a set of quantity limits.

Cap-and-trade systems generate a natural unit of exchange for linkage: allowances denominated in units of carbon content of fossil fuels or in units of CO₂ emissions. Hence, it would appear to be easier to link a domestic cap-and-trade system with other countries, particularly if they also employ cap-and-trade approaches (Jaffe, Ranson, and Stavins 2010). Recent research has found, however, that through appropriate mechanisms, it is possible that linkage could be carried out between a domestic carbon tax system and certain other policy instruments in other jurisdictions, although linking such heterogeneous policy instruments is considerably more challenging than the standard variety of linking two cap-and-trade regimes (Metcalf and Weisbach 2012; Bodansky *et al.* 2015; Mehling, Metcalf, and Stavins 2018).

2.2.8 Complexity and Administration

The simplest cap-and-trade system will involve greater complexity than the simplest carbon tax. But more important than the relative complexity of the two approaches is the fact that greater complexity in design elements frequently translates into greater administrative burden for the system's implementation.

A cap-and-trade system requires government to track allowances (at the end of compliance periods), possibly hold auctions, and develop other necessary rules. These include rules to prevent fraud and abuse, although, as noted above, issues of fraud have been rare with previous cap-and-trade applications. In contrast, a carbon tax is administratively simple and relatively straightforward to implement, given that the tax could incorporate existing methods for fuel-supply monitoring and reporting to the regulatory authority. It is reasonable to conclude that textbook applications of carbon taxes and cap-and-trade would yield greater administrative costs with the latter instrument (Goulder and Schein 2013).

Two possibly minor caveats are warranted. First, experience with cap-and-trade systems has demonstrated that the actual (marginal) costs of trading institutions have not been significant (Schmalensee and Stavins 2017a), although the fixed costs of setting up such institutions would presumably be greater than the fixed costs of setting up a carbon tax, since the latter could build on existing fossil-fuel excise taxes. Second, experience also suggests that a simple tax proposal might become considerably more complex as it passes through the legislature. Whether a policy as important as a national carbon tax would turn out to be “simple” in its design and implementation is at least open to question. That said, it is also true that the simplest cap-and-trade regimes become more complex as they work their way through legislative processes.

2.2.9 Political Resistance and Support for the Two Instruments

A common thread throughout this paper is endorsement of the principle that realistic versions of alternative policies should be analyzed and compared (Hahn and Stavins 1992). In a recent presentation, Goulder (2019a, 2019b) goes further by suggesting that when comparing

proposed climate policy instruments in an *ex ante* net-present-value analysis, it would be appropriate and desirable to weight the net benefits of each alternative by the probability of it being implemented within some period of time. (See related discussion in Section 3 below.) These probabilities would presumably be dependent upon current and future political factors.³⁰ In any event, this suggestion recognizes that political economy factors associated with adoption and implementation may be related to the merits or attributes of policy instruments.

In summary, Table 2 characterizes carbon taxes and cap and trade as being perfectly equivalent in regard to three attributes, incentives for emission reductions, aggregate abatement costs, and effects on competitiveness; nearly equivalent in regard to possibilities for raising revenue; similar in regard to costs to regulated firms and distributional impacts; somewhat distinct in regard to transaction costs; different in regard to performance in the presence of uncertainty; and significantly different in regard to effects on carbon price volatility, interactions with complementary policies, potential for market manipulation, and complexity and administrative requirements.

2.3 Hybrid Policy Instruments and a Policy Continuum

Some remaining differences between carbon taxes and cap and trade can diminish with implementation because hybrid policies that combine specific features of tax and cap-and-trade instruments can blur distinctions between the two. As already noted, the government can auction allowances in a cap-and-trade system, thereby reproducing many of the properties of a tax approach. In addition, mechanisms that reduce short-term price volatility and/or long-term price uncertainty in a cap-and-trade system bring it closer to a tax approach (Roberts and Spence 1976). These design elements include cost-containment mechanisms that place a cap or collar on allowance prices, banking that creates a floor under prices, and borrowing that provides flexibility similar to a tax. Hence, elements of design can foster symmetry between the two carbon-pricing instruments.

The use of a safety valve (hard price ceiling) or a price floor in a cap-and-trade system would appear to eliminate the key attribute that is strongly favored by environmental advocates – namely, lack of uncertainty regarding the quantity of emissions (Metcalf 2019) – because a price ceiling is achieved through the provision of additional allowances, while a binding price floor can result in fewer emissions than the stated cap level (Goulder and Schein 2013).

³⁰ In simple terms, as David Leonhardt has written in *The New York Times*, policies “are not efficient if they never pass” (Leonhardt 2019). However, making this analytical approach operational would require quantifying the probability of a specific policy being implemented (or rather, being implementable) over some period of time, which would be a function of current and future political factors. It is possible that quantifying those probabilities in a regulatory impact analysis could render the overall analysis less useful because of the degree of uncertainty that would inevitably be associated with the respective politically determined implementation probabilities.

However, in principle, the additional allowances the government offers for sale at the safety-valve price can come from an allowance reserve set aside for this purpose, or there can be borrowing from future allocations, so that total allowed emissions over time are unchanged, which is appropriate for the stock externality of climate change (Stavins 2008). Of course, the use of borrowing in a cap-and-trade regime raises a set of concerns that have prevented the adoption of borrowing in previous applications.

Likewise in a carbon tax system, certain elements of design can bring it closer to the properties of cap and trade. For example, emissions uncertainty with a tax can be reduced through a variety of means (Aldy *et al.* 2017), including a formula for adjusting the tax (Hafstead, Metcalf, and Williams 2017), periodic government review (Aldy 2018), or dedicating some tax revenue for emission mitigation activities (Goulder and Schein 2013; Murray, Pizer, and Reichert 2017). Some of these approaches may be thought of as rendering a pure carbon tax a hybrid instrument, just as a price collar may be said to render a pure cap-and-trade system a hybrid instrument.

Thus, the dichotomous choice between carbon taxes and cap-and-trade can be a choice of design elements along a policy continuum (Weisbach 2010). Ultimately, the design of either instrument is very consequential, and possibly more important than the choice between the two instruments (Stavins 1997; Keohane, Revesz, and Stavins 1998; Goulder and Schein 2013; Goulder and Hafstead 2018).

3. EMPIRICAL EVIDENCE: WHAT EXPERIENCE TELLS US

In this section I turn to an exploration of empirical evidence regarding the choice between carbon taxes and cap-and-trade with regard to the attributes and performance of the instruments in practice. In other words, I seek to identify lessons that can be learned from previous and current applications of these two carbon-pricing instruments.

Although more than 50 carbon-pricing policies have been implemented or are scheduled for implementation worldwide, including 26 carbon taxes and 25 emissions trading systems (Figure 1), I focus on a few of the more prominent examples of taxes and cap-and-trade that can offer the most useful lessons. Additional examples from South America are provided in the appendix.

3.1 Lessons from Experience with Cap-and-Trade

Among the most important applications of cap-and-trade in the United States have been the leaded gasoline phasedown (1982–1987),³¹ the SO₂ allowance trading system (1994–

31 The program was a tradable performance standard rather than a textbook cap-and-trade system.

2010), nitrogen oxides (NO_x) trading (1998–2009), and the Regional Clean Air Incentives Market (RECLAIM, 1993–present). In addition, two prominent U.S. cap-and-trade systems address CO₂ emissions: the Regional Greenhouse Gas Initiative (RGGI, 2009–present) and California’s system (AB-32³², 2013–present). The world’s largest carbon-pricing initiative is the European Union Emissions Trading System (EU ETS, 2008–present). Table 3 summarizes the geographic scope, sectoral coverage, time duration, allowance allocation method, cost-containment mechanisms, and environmental and economic performance of these seven important emissions trading systems.

There has also been rights trading for ozone-depleting substances (ODS) in several countries during the ODS phasedown from 1991 to 2000 under the 1987 Montreal Protocol (Klaassen 1999; Stavins 2003; U.S. Environmental Protection Agency 2014), as well as CO₂ cap-and-trade systems in New Zealand, Japan, South Korea, Kazakhstan, Quebec, and other jurisdictions. Also, an international CO₂ cap-and-trade system has been in place since 2008 under Article 17 of the Kyoto Protocol, but because the trading agents are nations, rather than firms, there has been little significant activity – an outcome that was anticipated (Hahn and Stavins 1999). As I discuss later, cap-and-trade systems are under development, planned, or proposed in many other jurisdictions (Schmalensee and Stavins 2017b).

Turning to lessons from these experiences:³³ First, in terms of the basics, cap and trade has long since proven to be environmentally effective and economically cost-effective (lead phase-down, SO₂ allowance trading³⁴). For example, it has been estimated that SO₂ trading reduced aggregate abatement costs by more than half compared with a commensurate, well-designed command-and-control approach (Metcalf 2019). The world’s most important CO₂ cap-and-trade system, the European Union Emissions Trading System (EU ETS), had its share of problems in its pilot phase (Metcalf 2019), but it has functioned essentially as anticipated since then (Ellerman, Convery, and Perthuis 2010). Relatively low allowance prices were a function of: (1) the degree of ambition of the cap; (2) the perverse effect of EU and member-state complementary policies, including those targeting renewable sources of energy and energy efficiency (see also Section 2.2.3); and (3) the 2008–2009 recession, which reduced energy demand and thus emissions. Of course, the lower allowance prices and fewer emissions reductions that occur with cap and trade during a recession are an economic virtue – that is, they are counter-cyclical and do not unduly burden industry when it is fundamentally unnecessary and unwise to do so. As with the EU ETS and RGGI, downstream,³⁵ sectoral programs have been commonly employed, although economy-wide systems have been shown to be feasible (AB-32).

32 AB-32 refers to Assembly Bill 32, “The Global Warming Solutions Act of 2006,” which established the California program.

33 Lessons learned from experiences in industrialized countries are emphasized, both because these contexts are more relevant to the United States and because of the greater availability of reliable evaluations.

34 The policy experiences listed in parentheses in this part of the paper refer to the sources of evidence for respective lessons.

35 That is, constraining emissions rather than the carbon content of fossil fuels.

Transaction costs have turned out to be low to trivial, particularly when compliance entities have been homogeneous (lead phasedown, SO₂ allowance trading). In particular, the SO₂ allowance trading system demonstrated that in properly designed systems, private markets can render transaction costs minimal (Schmalensee and Stavins 2013). In the context of climate policy, CO₂ emissions trading programs have been limited in scope of coverage, in contrast with textbook, upstream trading of rights associated with the carbon content of fossil fuels (World Bank Group 2016).

It is clear from basic theory and validated by experience that a robust market requires a cap that is significantly below business-as-usual emissions (SO₂ allowance trading,³⁶ RECLAIM). Likewise, high levels of compliance require monitoring, reporting, and verification combined with significant penalties for non-compliance (SO₂ allowance trading). Also, it has been shown to be important for final rules to be established well before commencement of a system's first compliance period to avoid unnecessary price volatility (SO₂ allowance trading, NO_x Budget, EU ETS).

Turning to specific elements of design, experience argues for systems that allow for a broad set of compliance alternatives, in terms of both timing and technological options. One of the most significant benefits of using carbon pricing – whether tax or cap and trade – is simply that technology and uniform performance standards are thereby avoided. Less flexible systems would not have led to the technological change that appears to have been induced by market-based instruments (Ellerman and Montero 1998; Bohi and Burtraw 1992; Keohane 2003; Schmalensee and Stavins 2013; Calel and Dechezlepretre 2016) or to the induced process innovations that have resulted (Doucet and Strauss 1994) in previous applications.

Provisions for banking of allowances have proven to be exceptionally important, as such inter-temporal trading has represented a large share of the realized gains from trade (lead phase-down, SO₂ allowance trading). In contrast, the absence of banking provisions can lead to price spikes (RECLAIM) and price collapses (EU ETS). More broadly, a changing economy can render a cap non-binding (RGGI, EU ETS) or drive prices to excessive levels (RECLAIM). Hence, there is a distinct role in cap-and-trade systems for price collars, which reduce the risk of unanticipated allowance price changes and price volatility by combining an auction price floor with an allowance reserve (RGGI, AB-32), a topic to which I return below.³⁷ On the other hand, excessive constraints on offset use can lead to a thin market that fails to be effective for cost-containment purposes (RGGI, AB-32).

36 For an analysis of how other government regulations (and some related judicial decisions) essentially eliminated the SO₂ market beginning in 2006, see Schmalensee and Stavins (2013).

37 A laboratory experiment by Holt and Shobe (2016), which compared price collars (as used in RGGI and AB-32) with quantity collars (modeled after the EU ETS Market Stability Reserve), found that the price collar was superior to the quantity collar in terms of reducing allowance price volatility and increasing efficiency.

Simplicity is important, and transparent formulas – including for allowance allocations – are difficult to contest or manipulate, particularly if rules are clearly defined up front, without ambiguity. By avoiding any requirements for prior government approval of individual trades, uncertainty and transaction costs are decreased (lead phasedown, SO₂ allowance trading).

The allocation of allowances is inevitably a major political issue, because of the large distributional impacts that can be involved. A striking and important experience has been that free allowance allocation has proven to foster political support, although it means that the opportunity is foregone to cut the program's overall social cost by refunding revenues from auctioning allowances through cuts of distortionary taxes (SO₂ allowance trading, AB-32). However, empirical experience has revealed that political pressures exist to use auction revenue not for the economist's favorite purpose of cutting distortionary taxes, but to fund new or existing government programs or relieve deficits (AB-32, RGGI). Indeed, cap-and-trade allowance auctions can and have generated very significant revenue for governments (RGGI, AB-32).

Another prominent political concern with cap-and-trade systems has been the possibility of emissions and economic leakage and related competitiveness impacts. In practice, leakage from cap-and-trade systems can range from non-existent (lead phasedown) to potentially quite serious (RGGI). It is most likely to be significant for programs of limited geographic scope, particularly in the power sector because of interconnected electricity markets (RGGI, AB-32). Attempts to reduce leakage and competitiveness risks through free allocation of allowances do not address the problem (EU ETS), but an output-based, updating allocation – in principle – can do so (AB-32).

Carbon pricing (through cap and trade or taxes) may be said to be necessary to address climate change, but it is surely not sufficient, due to the limited sectoral scope of some carbon pricing regimes and – more broadly – due to the presence of other market failures that inhibit the perfect functioning of markets. Hence, there can be an appropriate role for complementary policies. But actual suites of so-called “complementary policies” have frequently conflicted with, rather than complemented, carbon pricing because they address emissions under the cap, thereby relocating rather than reducing emissions, driving up abatement costs, and suppressing allowance prices (Organization for Economic Cooperation and Development 2011). This perverse situation has characterized two of the most prominent applications of cap and trade in the climate policy context (AB-32, EU ETS).

The degree of perverse interaction between a complementary policy and a cap-and-trade system within which it is nested can be characterized by the difference in marginal abatement costs between the cap-and-trade system and the complementary policy. In the case of California, these marginal costs are known because they are represented by the allowance price in the AB-32 cap-and-trade system and by a separate allowance price under a distinct trading system that operates as part of the state's refinery-based Low Carbon Fuel Standard (LCFS).

In February 2019, AB-32 allowances were trading at about \$16/ton, while LCFS allowances were trading at approximately \$200/ton (Lithgow 2019) – indicating a dramatic departure from an overall system of cost-effective emissions reduction.

These perverse interactions, frequently characterized as the “waterbed effect” in the European context (Fankhauser, Hepburn, and Park 2010; Perino 2018), may be partially alleviated by planned reforms employing “market stability reserves” in the EU ETS, California, and RGGI (Edenhofer, *et al.* 2017; Perino, Ritz, and van Benthem 2019).

3.2 Lessons from Experience with Carbon Taxes

In contrast with the history of cap-and-trade systems, the lion’s share of implemented pollution taxes have been focused on CO₂ (or related energy generation), including 29 carbon taxes identified by the World Bank as of 2019 (World Bank Group 2019). As with cap and trade, I focus on the most prominent applications: carbon taxes that are set at particularly high levels in several northern European countries and the more recent carbon tax in British Columbia. Additional insights from South America are provided in the appendix.

3.2.1 Northern European Carbon Taxes

European carbon taxes have frequently been introduced as elements of broader energy and excise tax reform initiatives, as opposed to reflecting a singular focus on reducing CO₂ emissions (Murray and Rivers 2015). The systems have had different scopes of coverage, different tax rates, and many are coincident with – if not linked with – the EU ETS, making it difficult to assess impacts (Murray and Rivers 2015). In the 1990s, several northern European countries imposed carbon taxes to limit their GHG emissions as part of broader tax policies.

Norway implemented a carbon tax in 1991 that varied in its level across sectors of the economy, despite the fact that cost-effective abatement would call for a uniform tax. By 1999, facilities using coal paid \$24 per ton of CO₂ (tCO₂) for coal for energy purposes and \$19/tCO₂ for coal for coking purposes (Bruvoll and Larsen 2004), but these activities were completely exempted from the carbon tax beginning in 2003. In the transportation sector, by 2009, the Norwegian carbon tax was \$58/tCO₂ on gasoline and \$34/tCO₂ on diesel. In 2009, the carbon tax applied to about 55% of Norwegian GHG emissions, while an emission trading scheme linked to the EU ETS covered an additional 13% of emissions.³⁸ In 2003, Norway also introduced a tax of \$33 per ton CO₂-equivalent on hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs), to slow the growth rate of these potent GHGs.

Sweden implemented a carbon tax of \$33/tCO₂ in 1991 as a part of a fiscal reform that cut high income tax rates (Speck 2008). The carbon tax has since increased to approximately

³⁸ GHG emissions in the offshore oil sector, representing 24% of Norway’s emissions, are covered by both a (lower) carbon tax and the emission trading scheme.

\$120/tCO₂ (based on the February 2019 exchange rate). When the carbon tax was implemented, Sweden – as a relatively small, open economy – reduced its general energy tax on many of the sources bearing the carbon tax; refineries, steel, and other primary metal industries also received exemptions from the carbon tax (Daugjberg and Pedersen 2004). In addition, those industries covered by the EU ETS were exempted from the carbon tax, but, in 2018, these exemptions were partially removed.³⁹ The tax has generated considerable revenue for the general budget, as there is no earmarking of tax revenues in Sweden (Government Offices of Sweden 2019). However, because of its (fully intended) impacts, revenues from the tax on heating fuels, for example, have fallen due to decreased use and consequent erosion of the tax base.

Denmark implemented a carbon tax of about \$18/tCO₂ in 1992; it reduced the tax to \$17/tCO₂ in 2005, where it has remained (Speck 2008; World Bank Group 2018). Manufacturing sectors face lower tax rates: up to 90% below the standard rate, depending on their energy intensity.

Finland has imposed a general tax on energy coupled with a surtax based on the carbon content of the energy since 1997. Like other northern European nations, Finland lowers its carbon tax for industries covered by the EU ETS. Since 2008, the carbon surtax has been about \$28/tCO₂, although natural gas faces half this rate (World Bank Group 2018).

Some of the carbon taxes in northern Europe are at the highest levels of any carbon prices worldwide (Figure 1), although implementation has yielded significant variations in the effective tax per unit of CO₂ across fuels and industries within each country, contrary to the cost-effective prescription of a common price on carbon. In addition, fiscal cushioning of the impact of carbon taxes, by adjustments to pre-existing energy taxes, and of the impact of the EU ETS, by adjustments to pre-existing carbon taxes, is common, especially for those industries expressing concerns about their international competitiveness (Aldy and Stavins 2012). Nevertheless, these countries were the first to demonstrate that carbon taxes could be employed to reduce GHG emissions while raising revenue to finance government spending or lower other tax rates (Organization for Economic Cooperation and Development 2001). Unfortunately, there is little empirical evidence of the emissions impacts of these taxes.

3.2.2 British Columbia Carbon Tax

The Canadian province of British Columbia has had in place since 2008 a carbon tax that comes closest to the version of an ideal carbon tax typically recommended by economists

³⁹ Since January 1, 2018, previously exempted emissions from combined heat and power plants that are also covered by the EU ETS are being taxed at 11% of the full tax rate. The tax level for other heat production covered by the EU ETS increased from 80% to 91% of the full rate, while industrial facilities covered by the EU ETS are still entirely exempt from the carbon tax. In addition, since January 1, 2018, the carbon tax rate on industrial facilities not covered by the EU ETS became aligned with the general tax rate. Prior to this date, a lower tax rate was applied to these facilities (World Bank Group 2019).

(Metcalf 2019). As such, it has been characterized – like the U.S. SO₂ allowance trading system – as “a grand policy experiment” (Stavins 1998; Murray and Rivers 2015). The tax is one part of British Columbia’s plan to reduce provincial GHG emissions by 33% by 2020 (British Columbia 2007). The carbon tax is intended to be economy-wide (covering approximately 70%–75% of emissions).

British Columbia’s tax began at \$7.50 per ton of CO₂-equivalent emissions in 2008, increasing by \$3.75/tCO₂-equivalent per year, such that it now amounts to \$27/tCO₂-equivalent,⁴⁰ and is scheduled to reach \$38/tCO₂-equivalent in 2021. The tax is collected upstream at the wholesale level (fuel distributors), based on the carbon content of fuels (Duff 2008); according to Metcalf (2019, p. 50), it covers “carbon emissions of all hydrocarbon fuels burned in the province.” Exemptions from the tax include fuels exported from British Columbia,⁴¹ fuels used by aviation and shipping into or out of the province; operations and fuels used in agriculture (since 2012); all non-fossil-fuel GHG emissions, including from industrial processes, landfills, forestry, and agriculture; and methane emissions from the production and transmission of fossil fuels.

Originally, by law, 100% of the tax revenue was to be refunded through tax cuts to businesses and individuals, with low-income individuals further protected through a targeted tax credit. But, over time, the policy has evolved from using revenues to cut distortionary taxes to more focused use of specific tax cuts for specific sectors and locations (Murray and Rivers 2015). That said, combining general tax cuts and those targeted to specific sectors, companies, and locations, the current disposition of tax revenues is as follows: 50% to business tax rate reductions and corporate income tax credits, 23% to personal income tax cuts, and 25% to equal lump-sum rebates to households (Goulder and Hafstead 2018). According to an analysis by Beck *et al.* (2015), when taking into account both its use-side *and* source-side impacts (see above), the British Columbia carbon tax turns out to be progressive in its distributional impacts, even before considering the consequences of specific uses of revenue.

In terms of its performance, the empirical evidence is unclear. One estimate is that the tax policy has reduced the province’s CO₂ emissions by 5%–10%, with little negative impact on the economy (Metcalf 2019) but with unknown emissions leakage (Murray and Rivers 2015). Other research, however, has questioned whether emissions have been reduced (Pretis 2019).

3.3 Lessons from Experience with Hybrid Policy Instruments

As discussed above, hybrid policies that combine features of tax and cap-and-trade can blur distinctions between the two. Empirical experience with cap-and-trade systems suggests a

40 The April 2019 exchange rate has been used to convert Canadian dollars to U.S. dollars.

41 Note that virtually all of the coal mined in British Columbia is exported (Murray and Rivers 2015). About 90% of the province’s coal production is steel-producing coking coal. The province does not use coal for power generation.

trend of greater use, over time, of auctioning of allowances, as in the California AB-32 (and more recent AB-398) system, RGGI, and the EU ETS.

The blurring of the two approaches can become even more pronounced with the use of cost-containment elements in cap-and-trade systems, which reproduce many of the properties of a tax approach, as do mechanisms that reduce short-term price volatility and/or long-term price uncertainty in a cap-and-trade system. Banking provisions have been common in all CO₂ cap-and-trade systems (and nearly all cap-and-trade systems for other pollutants), but borrowing provisions have only been present implicitly in the form of compliance periods that have ranged from one to five years.

The California system, as well as RGGI, have employed safety-valve prices, \$10/tCO₂ in the case of RGGI and greater than \$50 in the California system. In fact, both systems now employ price collars, combining an auction price floor with a price that triggers availability from an allowance reserve. However, these approaches provide a “soft ceiling” on prices (or a soft price collar) because there is a finite supply of allowances in the reserve. California’s post-2020 system will include a hard ceiling on prices, in which there will be no limit on the supply of allowances available at a specified, escalating price level (Schatzki and Stavins 2018).

4. CONCLUSIONS

In principle, either carbon-pricing instrument could be used in a national system to achieve meaningful reductions of CO₂ emissions, such as the 2025 target of 26%–28% below the 2005 level, expressed in the U.S. NDC under the Paris Agreement (Chen and Hafstead 2018). When carbon taxes and carbon cap-and-trade systems are designed in ways that make them truly comparable, their characteristics and outcomes are similar, and in some cases fully equivalent in terms of emission reductions, abatement costs, possibilities for raising revenue, costs to regulated firms when revenue-raising instruments are employed, distributional impacts, and effects on competitiveness.

On some other dimensions, there can be real differences between the performance of these two approaches. Some of these dimensions favor carbon taxes, some favor cap and trade, and most depend on respective design elements. In particular, the tax approach is clearly favored by three elements: complexity and administrative requirements, interactions with complementary policies, and effects on carbon-price volatility. Cap and trade is favored in terms of ease of linkage with policies in other jurisdictions and possibly by its anticipated performance in the presence of uncertainty. However, neither transaction costs nor the potential for market manipulation with cap and trade appear to be particularly important, as examined (in particular) in the U.S. context.

Thus, the available evidence supports the conclusion that neither approach dominates the other on the merits, and any overall ranking would depend on the weights given to the various dimensions of difference (Goulder and Schein 2013; Goulder and Hafstead 2018), as well as on the relative probability of good design.

Much the same can be said with regard to how carbon pricing has been implemented in practice: There is decidedly mixed evidence regarding which of the two carbon-pricing approaches (if either) is more likely to be adopted at the national level in the United States in the future. Thus, there is not a strong case for the superiority of taxes or trading with regard to either their merits or their likelihood of adoption, and differences in performance that are a function of specific design of the two instruments dominate differences in the performance of the instruments themselves.

Two major conclusions therefore stand out. One is that the specific designs of carbon taxes and cap-and-trade systems may be more consequential than the choice between the two instruments. Many differences fade with specific implementation decisions, and what appears to be a dichotomous choice between two distinct policy instruments often turns out to be a choice of design elements along a policy continuum. The other conclusion that stands out is that the merits of the two policy instruments – theoretically and empirically – are not entirely separate from issues pertaining to adoption and implementation.

All of this serves as a reminder of the importance of avoiding comparisons of policy instruments where one instrument is idealized and the other is realistic; rather, comparisons are best made between idealized versions of two instruments or – better yet – realistic versions of both (Hahn and Stavins 1992). This is consistent with the notion of comparing proposed climate policy instruments by weighting the net benefits of each by the probability of it being implemented within some time period – an approach that would essentially merge analyses based on merits and analyses based on the political economy of adoption and implementation. National policy instruments that appear impeccable from the vantage point of Berkeley, Cambridge, Madison, or New Haven, but that consistently prove infeasible in Washington, D.C. can hardly be considered “optimal” (Stavins 2012).

It may be reasonable to stipulate (as the lawyers say) that in regard to relative simplicity, carbon taxes have the upper hand over cap and trade. But real carbon taxes “are among the least used climate policy instruments” (Carattini, Carvalho, and Fankhauser 2017), with only twenty countries and two Canadian provinces having implemented carbon taxes as of 2018, and South Africa now having delayed implementation. Also, carbon tax proposals have been undone, reversed, or have simply failed – sometimes at very advanced stages politically – such as in France and Switzerland in 2000, in Australia in 2014, and in the State of Washington in 2016 and 2018 (Carattini, Carvalho, and Fankhauser 2017; Anderson, Marinescu, and Shor 2018). Cap and trade has not fared much better (Figure 1), having failed at the national level

in the United States during the Obama administration (although at the sub-national level, cap-and-trade systems are poised to be launched in 2019 in three states).

This track record can be compared with the 176 countries that had renewable energy policies and/or energy efficiency standards, and another 110 national and sub-national jurisdictions with feed-in tariffs, as of 2016 (Carattini, Carvalho, and Fankhauser 2017). So, thinking about how to make carbon taxes or cap-and-trade more politically acceptable may be a critical step for more effective climate policy action.

4.1 Can Carbon Pricing be Made More Politically Acceptable?

Can carbon taxes or cap and trade be made more acceptable by designing them in ways that respond to voter concerns? This is a particularly important question given the considerable ambiguity regarding the superiority of either of these instruments on their merits, and the reality that specific elements of design can minimize, if not eliminate, remaining differences.

Survey and other evidence indicate that a set of public perceptions – at least some of which are inaccurate – are primary factors behind aversion to carbon taxes. Examples of such perceptions include: the personal costs are too great, the policy is regressive, the policy could damage the economy, the policy will not discourage carbon-intensive behavior, and governments just want to increase their revenues (Carattini, Carvalho, and Fankhauser 2017).⁴² This suggests that one way to improve public acceptability could be through better informing the public about the real nature and consequences of carbon-pricing policies.

Another way to increase public acceptability could be through judicious policy design. Several routes might be employed to make carbon taxes or cap-and-trade more politically acceptable, while departing from what may be the most efficient design. One approach would be to phase in taxes or caps over time, since a lower carbon price is presumably more politically acceptable. Then, as aversion may abate over time, prices can be increased (Carattini, *et al.* 2017). This is the route that California and British Columbia have taken with their respective carbon-pricing policies. A gradual phase-in also reduces the stranded asset problem (Rozenberg, Vogt-Schilb, and Hallegatte 2019), even if the outcome is less effective in the short run and hence less efficient. There is a risk that the carbon price would become stuck at too low a level, so a commitment device may be appropriate, such as making the emissions cap or tax-rate trajectory part of legislation, as was done with the SO₂ allowance trading program and the British Columbia and Swedish carbon taxes.

A second, very important design modification that would frequently depart from the most efficient design would be to earmark carbon tax or auctioned allowance revenue to finance

⁴² This list of factors, as well as the potential means of addressing them through modifications of carbon tax design I subsequently describe, are drawn from Carattini, Carvalho, and Fankhauser (2017) and a large number of other studies cited therein.

additional climate mitigation (Amdur, Rabe, and Borick 2014; Carattini, Carvalho, and Fankhauser 2017; Kotchen, Turk, and Leiserowitz 2017). This is in contrast to economists' preference on efficiency grounds for treating carbon tax proceeds as part of general revenues so that the tax system as a whole can be optimized, such as through cutting distortionary taxes. There is, in fact, substantial evidence of voter preference for such earmarked use of revenues, with particular receptivity to using revenue for low-carbon research and development, and subsidies to promote deployment. The former, at least, can be part of an efficient portfolio of complementary climate policies due to the separate market failure stemming from the public-good nature of information. Of course, in principle, earmarking could be phased down over time.

A third and final design modification that departs from an efficient approach is to use revenues for fairness purposes – such as with a progressive, revenue-neutral carbon tax or cap-and-trade system with lump-sum rebates of tax (or auction) revenue or rebates more targeted to cushion impacts on low-income or other particularly burdened constituencies (Amdur, Rabe, and Borick 2014; Carattini, Carvalho, and Fankhauser 2017) – rather than recycling carbon tax revenue through cuts in distortionary taxes (Goulder and Hafstead 2018; Metcalf 2019). A diverse set of surveys indicates voter support for using carbon-pricing revenue to ease impacts on low-income households (Carattini, Carvalho, and Fankhauser 2017). Proposals from very different political perspectives have favored this approach, using so-called carbon dividends with carbon taxes or as part of a “cap-and-dividend” trading system (Boyce and Riddle 2007; Sedor 2015; U.S. House of Representatives 2018; Akerlof *et al.* 2019; Harder 2019).

Survey evidence does not indicate support from the general public for using revenue to cut distortionary taxes. In fact, surveys in Denmark, Germany, the United Kingdom, and other countries have found cutting other taxes to be the least popular strategy for the use of carbon pricing revenues (Carattini *et al.* 2017). Why might this be? It could be that voters do not understand the logic of the “double dividend” (Goulder 1995), which can come from cutting these other taxes. Or it may reflect a simple lack of trust of politicians and government – that is, doubt that governments will actually cut other taxes or fear that the “wrong people” would benefit. In general, survey evidence indicates that public support, both for carbon taxes and for carbon cap and trade, is linked with proposed uses of revenue (Amdur, Rabe, and Borick 2014; Mills, Rabe, and Borick 2015; Kotchen, Turk, and Leiserowitz 2017).

4.2 Can the Rejection of National Carbon Cap-and-Trade Help Carbon Tax Proposals?

Political polarization in the United States – which began some five decades ago and accelerated after 1990 – has decimated what had long been the key source of political support in Congress for environmental and energy action: namely, the middle, including both moderate Republicans and moderate Democrats (Stavins 2011; Schmalensee and Stavins 2013).

Whereas congressional debates about environmental and energy policy had long featured regional politics, these debates are now fully and simply partisan. In this political maelstrom, the failure of cap-and-trade climate policy in the U.S. Senate in 2010 was essentially collateral damage in a much larger political war.

The successful political battle against the Obama administration's CO₂ cap-and-trade legislation featured the demonization of that instrument as “cap and trade.” Does the consequent reputational loss for cap and trade present an opening for serious consideration of the other carbon-pricing instrument: a carbon tax? The ongoing challenge of large budgetary deficits may increase the political feasibility of new sources of revenue. When and if that happens, consumption taxes (as opposed to traditional taxes on income and investment) could receive heightened attention, and primary among these might be energy or carbon taxes.

Surely this opening already exists in the broader policy community, with support not only from the usual Democratic sources but also from prominent Republican academic economists and former high government officials. The January 16, 2019 economists' statement on a carbon dividend plan in the *Wall Street Journal* (Akerloff *et al.* 2019) and support from the Niskanen Center provide evidence of the diversity of bipartisan support for a carbon tax (typically in the form of a carbon dividend plan) in the broader policy community.

What about in the real political world of those currently holding elective office in the federal government? The good news is that a carbon tax is *not* “cap and trade.” That may help with the political messaging. But if conservatives were able to tarnish cap and trade as “cap and trade,” it surely will not be very difficult to label a tax (or a “fee”) – as a tax. In addition to opposition from the right, it is – as of now – questionable whether the new left of the Democratic Party in Congress will want a carbon tax to be part of its “Green New Deal.” So, for the short term, national carbon pricing of either type may continue to face an uphill battle in the United States.

Therefore, in addition to economic research on the judicious design of less-than-efficient carbon-pricing policies, economists can be effective by working to catch up with the political world by examining better design of non-pricing climate policy instruments, such as clean energy standards.⁴³ But at some point the politics *will* change and it is important to be ready, which is why – for the long term – ongoing research on carbon-pricing instruments is very much warranted, particularly if it is carried out in the context of real-world politics and focuses on policies that are likely at some point to prove feasible.

43 For example, the “Clean Energy Standard Act of 2019,” Senate Bill 1359, introduced on May 8, 2019, would establish a standard for clean generation of electricity with a market-oriented credit trading program.

Table 1: Implemented and Scheduled Carbon-Pricing Initiatives, 1990–2020

Initiative	Type	Status	Type of Jurisdiction	Jurisdiction	Year	GHG Emissions [MtCO ₂ e]
Alberta Carbon Competitiveness Incentive Regulation	Trading	Implemented	Sub-National	Alberta	2007	120
Alberta Carbon Tax (repealed, May 2019)	Tax	Implemented	Sub-National	Alberta	2017	109
Argentina Carbon Tax	Tax	Scheduled	National	Argentina	2019	79
Australia Emissions Reduction Fund Safeguard Mechanism	Trading	Implemented	National	Australia	2016	381
BC Greenhouse Gas Industrial Reporting and Control Act	Trading	Implemented	Sub-National	British Columbia	2016	0
BC Carbon Tax	Tax	Implemented	Sub-National	British Columbia	2008	42
Beijing Emissions Trading System	Trading	Implemented	Sub-National	Beijing	2013	85
California AB-32/ AB-398 Cap-and-Trade System	Trading	Implemented	Sub-National	California	2012	378
Canada Federal Output-Based Pricing System	Trading	Scheduled	National	Canada	2019	?
Canada Federal Carbon Tax	Tax	Scheduled	National	Canada	2019	?
Chile Carbon Tax	Tax	Implemented	National	Chile	2017	47
China National Emissions Trading System	Trading	Scheduled	National	China	2020	3,232
Chongqing Emissions Trading System	Trading	Implemented	Sub-National	Chongqing	2014	97
Colombia Carbon Tax	Tax	Implemented	National	Colombia	2017	42
Denmark Carbon Tax	Tax	Implemented	National	Denmark	1992	22
European Union Emissions Trading System	Trading	Implemented	Regional	EU plus Nor., Ice., & Lich.	2005	2,132
Estonia Carbon Tax	Tax	Implemented	National	Estonia	2000	1
Finland Carbon Tax	Tax	Implemented	National	Finland	1990	25
France Carbon Tax	Tax	Implemented	National	France	2014	176

Table 1 (continued)

Initiative	Type	Status	Type of Jurisdiction	Jurisdiction	Year	GHG Emissions [MtCO ₂ e]
Fujian Emissions Trading System	Trading	Implemented	Sub-National	Fujian	2016	200
Guangdong Emissions Trading System	Trading	Implemented	Sub-National	Guangdong	2013	366
Hubei Emissions Trading System	Trading	Implemented	Sub-National	Hubei	2014	162
Ireland Carbon Tax	Tax	Implemented	National	Ireland	2010	31
Japan Carbon Tax	Tax	Implemented	National	Japan	2012	999
Kazakhstan Emissions Trading System	Trading	Implemented	National	Kazakhstan	2013	183
Korea Emissions Trading System	Trading	Implemented	National	Korea	2015	453
Latvia Carbon Tax	Tax	Implemented	National	Latvia	2004	2
Liechtenstein Carbon Tax	Tax	Implemented	National	Liechtenstein	2008	0
Massachusetts Cap-and-Trade System	Trading	Implemented	Sub-National	RGGI States	2018	10
Mexico Carbon Tax	Tax	Implemented	National	Mexico	2014	307
New Zealand Emissions Trading System	Trading	Implemented	National	New Zealand	2008	40
Norway Carbon Tax	Tax	Implemented	National	Norway	1991	40
Poland Carbon Tax	Tax	Implemented	National	Poland	1990	16
Portugal Carbon Tax	Tax	Implemented	National	Portugal	2015	21
Quebec Cap-and-Trade System	Trading	Implemented	Sub-National	Quebec	2013	67
Regional Greenhouse Gas Initiative	Trading	Implemented	Sub-National	RGGI States	2009	94
Saitama Emissions Trading System	Trading	Implemented	Sub-National	Saitama	2011	7
Shanghai Emissions Trading System	Trading	Implemented	Sub-National	Shanghai	2013	170
Shenzhen Emissions Trading System	Trading	Implemented	Sub-National	Shenzhen	2013	61
Singapore Carbon Tax	Tax	Scheduled	National	Singapore	2019	42
Slovenia Carbon Tax	Tax	Implemented	National	Slovenia	1996	5
South Africa Carbon Tax	Tax	Scheduled	National	South Africa	2019	360

Table 1 (continued)

Initiative	Type	Status	Type of Jurisdiction	Jurisdiction	Year	GHG Emissions [MtCO ₂ e]
Spain Carbon Tax	Tax	Implemented	National	Spain	2014	9
Sweden Carbon Tax	Tax	Implemented	National	Sweden	1991	26
Switzerland Emissions Trading System	Trading	Implemented	National	Switzerland	2008	6
Switzerland Carbon Tax	Tax	Implemented	National	Switzerland	2008	18
Tianjin Emissions Trading System	Trading	Implemented	Sub-National	Tianjin	2013	118
Tokyo Cap-and-Trade System	Trading	Implemented	Sub-National	Tokyo	2010	14
UK Carbon Price Floor	Tax	Implemented	National	United Kingdom	2013	136
Ukraine Carbon Tax	Tax	Implemented	National	Ukraine	2011	287
Washington State Clean Air Rule	Trading	Implemented	Sub-National	Washington	2017	58

SOURCE: World Bank Group. 2018. State and Trends of Carbon Pricing. Washington, D.C.

Table 2: Similarities and Differences Between Carbon Taxes and Carbon Cap-and-Trade

Perfectly Equivalent	Nearly Equivalent	Similar	Some Distinctions	Differences	Significant Differences
Incentives for Emission Reductions					
Aggregate Abatement Costs					
Effects on Competitiveness					
	Possibilities for Raising Revenue				
		Costs to Regulated Firms			
		Distributional Impacts			
			Transaction Costs		
				Performance in the Presence of Uncertainty	
				Ease of Linkage with Other Jurisdictions	
					Effects on Carbon Price Volatility
					Interactions with Complementary Policies
					Potential for Market Manipulation
					Complexity and Administrative Requirements

Table 3: Most Important Cap-and-Trade Systems

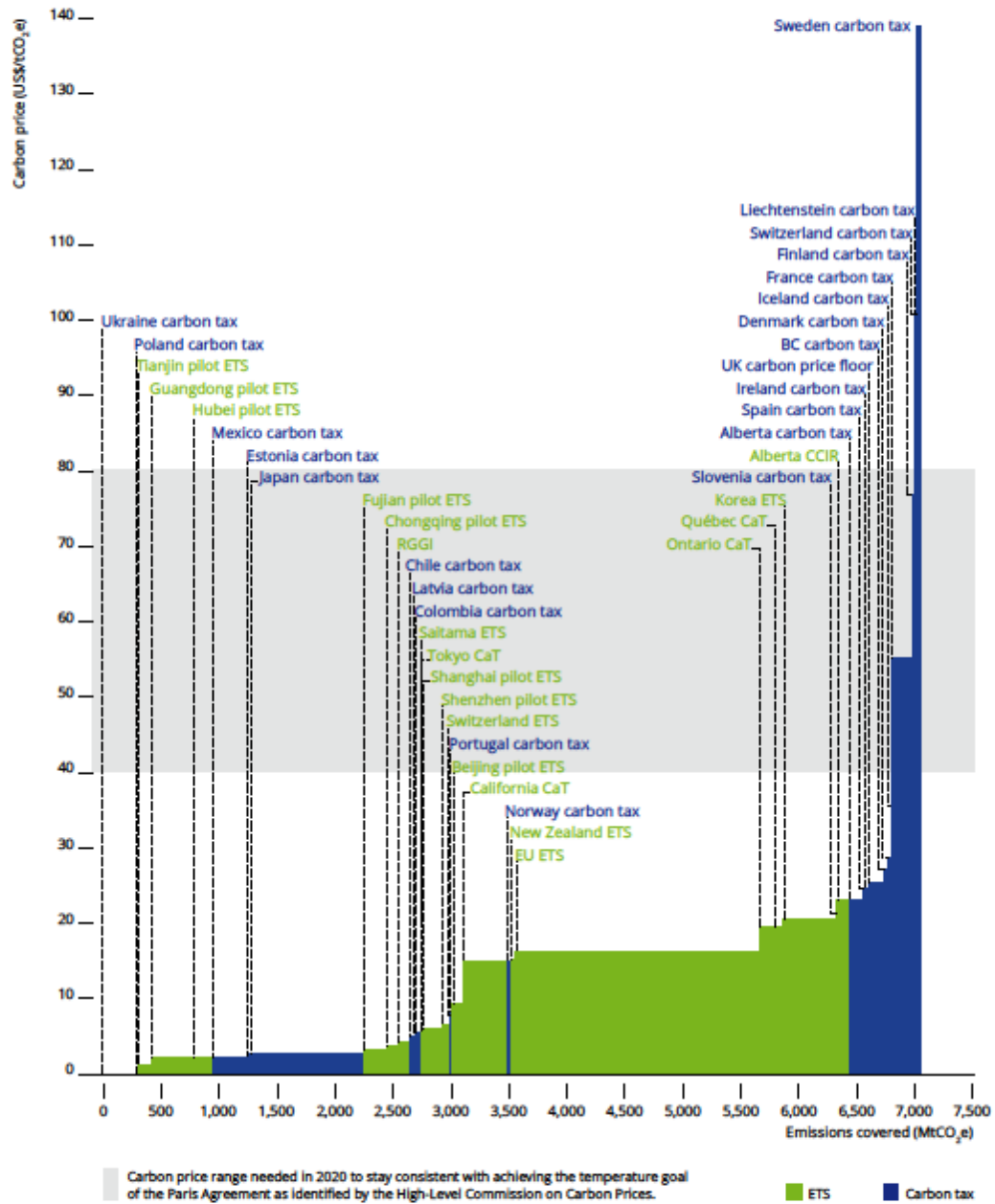
System	Geographic Scope	Coverage & Sectors	Time Period	Allowance Allocation Method	Cost Containment Mechanisms	Environmental and Economic Performance
Leaded Gasoline Phasedown	USA	Gasoline from Refineries	1982–1987	Free	Banking	Phasedown completed successfully, faster than anticipated, with cost savings of 20% or \$250 million/year
Sulfur Dioxide Allowance Trading	USA	SO ₂ from Electric Power	1995–2010	Free	Banking	Cut SO ₂ emissions by half, with cost savings of \$1 billion/year, but market closed due to judicial actions
Regional Clean Air Incentives Market (RECLAIM)	South Coast Air Quality Management District, CA	NO _x & SO ₂ from Electric Power & Industrial Sources	1993–present	Free	---	Emissions lower than with parallel regulations; un-quantified cost savings; electricity crisis caused allowance price spike and temporary suspension of market
NO_x Trading in the Eastern United States	12-21 U.S. States	NO _x from Electric Power & Industrial Sources	1999–2008	Free	---	Significant price volatility in first year; NO _x emissions declined from 1.9 (1990) to 0.5 million tons (2006); cost savings 40%–47%
Regional Greenhouse Gas Initiative	Nine north-eastern U.S. States	CO ₂ from Electric Power	2009–present	Nearly 100% Auction	Banking, Cost-Containment Reserve, Auction Reservation Price	Cap non-binding then barely binding due to low natural gas prices; has generated more than \$1 billion for participating states

Table 3 (continued)

System	Geographic Scope	Coverage & Sectors	Time Period	Allowance Allocation Method	Cost Containment Mechanisms	Environmental and Economic Performance
AB-32 and AB-398 California Cap-and-Trade	California, USA	CO ₂ from Electric Power, Industrial, & Fuels	2013–2020 2021–2030	Transitions from Free to Auction	Banking, Allowance Price Containment Reserve, Auction Reservation Price	Covers 85% of emissions, reduced 40% below 1990 by 2030; reduces competitiveness effects w/output-based updating (OBU) allocation; linked with Quebec cap-and-trade system
European Union Emissions Trading System	27 EU Member States plus Iceland, Lichtenstein, & Norway	CO ₂ from Electric Power, Large Industrial, & Aviation	2005–Present	Transitions from Free to Increased Use of Auctions	Banking after 2008, previous use of offsets from CDM	Covers half of emissions, has cut abatement costs by about 50% compared with no trading; over-allocation by member states in pilot phase; suppressed allowance prices due to "complementary policies," CDM glut, slow economic recovery

SOURCE: Adapted from Schmalensee and Stavins 2017a. Sources include: Carlson et al. 2000; Cludius et al. 2019; Ellerman et al. 2000; Ellerman and Buchner 2007; Fowlie, Holland, and Mansur 2012; Keohane 2003; Schmalensee and Stavins 2013, 2017a, 2017b; and U.S. Environmental Protection Agency 1985.

Figure 1: Carbon Price and Emissions Coverage of Implemented Carbon-Pricing Initiatives



Note: The Australia ERF Safeguard Mechanism, British Columbia GGIRCA, Kazakhstan ETS and Washington CAR are not shown in this graph as price information is not available for those initiatives. The carbon tax rate applied in Mexico and Norway varies with the fossil fuel type and use. The carbon tax rate applied in Denmark varies with the GHG type. The graph shows the average carbon tax rate weighted by the amount of emissions covered at the different tax rates in those jurisdictions.

SOURCE: World Bank Group 2018

APPENDIX: CARBON PRICING IN SOUTH AMERICA

Marcos Barrozo and Robert Stowe⁴⁴

The Harvard Project on Climate Agreements, directed by the author of the main paper (Stavins), has conducted preliminary research on carbon pricing in South America, focusing in large part on the political economy of adoption and implementation. Included in this appendix are preliminary insights from four interviews with policy makers and experts from the private sector (June–August 2019);⁴⁵ presentations during carbon-pricing sessions at the Latin America and Caribbean Climate Week, in Salvador, Brazil (August 19–23, 2019);⁴⁶ and a preliminary review of relevant literature and reporting.

This appendix addresses carbon pricing in Argentina, Chile, and Colombia, which have advanced carbon-pricing policy further than other South American countries.⁴⁷ Interview data were obtained on Chile and Colombia.

Status of Carbon Pricing in South America

Chile

Chile was the first South American country to adopt a carbon-pricing policy, in the form of a carbon tax that was part of a broader tax-reform package – partly intended to simplify the tax code – enacted in September 2014. The tax began to be assessed in January 2017, with obligations for 2017 payable April 2018.⁴⁸ The Chilean carbon tax started and remains at \$5/tCO₂ and is imposed on fossil-fuel-fired power plants with installed capacity of at least 50 megawatts (MW).⁴⁹

⁴⁴ Marcos Barrozo is a Ph.D. student in public policy at Harvard Kennedy School. Robert Stowe is Co-Director of the Harvard Project on Climate Agreements.

⁴⁵ Interviewees were Alexis L. Leroy, Founder, ALLCOT Group; Jorge Gómez, Advisor on Environment and Climate Change, Association of Power Generators in Chile; and two government officials focused on carbon pricing – one each in Colombia and Chile – who wished to remain anonymous. Some speakers at Climate Week panels are cited by name.

⁴⁶ Agenda at: https://unfccc.int/sites/default/files/resource/LACCW_2019_EVENT_GUIDE.pdf. See pp. 9–10 for carbon-pricing events.

⁴⁷ While the scope of the current research is constrained to South America, note that Mexico has implemented a carbon tax and is in the process of implementing a GHG emissions trading system. World Bank Group. June 2019. *State and Trends of Carbon Pricing 2019*. p. 40 and figures elsewhere. <https://openknowledge.worldbank.org/handle/10986/31755>.

⁴⁸ World Bank. November 2017. *State and Trends of Carbon Pricing 2017*. p. 47, fn. 116. <https://openknowledge.worldbank.org/handle/10986/28510>; Government of Chile. “Green Taxes.” www.precioalcarbonochile.cl/en/ipc-en-chile (click on “Green Taxes in Chile” in the menu at the bottom of the page).

⁴⁹ Reuters. “Chile Becomes the First South American country to Tax Carbon.” September 26, 2014. www.reuters.com/article/carbon-chile-tax/chile-becomes-the-first-south-american-country-to-tax-carbon-idUSL6N0RR4V720140927; IETA. September 2018. “Carbon Pricing Across the Americas.” p. 9. https://ieta.org/resources/Resources/GHG_Report/2018/IETAInsights2018Q3_CarbonPricingintheAmericas.pdf.

Another tax-reform bill, introduced in 2018 in the Chilean legislature, proposes to broaden the scope of the carbon tax to other sectors, reduce the emissions threshold, and allow the use of domestic offsets.⁵⁰ Concerns about competitiveness and emissions leakage have been one factor – among many not related to GHG emissions in such a complex bill – contributing to delays in consideration. The tax reform bill was passed by the lower house (Chamber of Deputies) of the Chilean legislature in August 2019, but the upper house (Senate) will probably not complete consideration until 2020.

Chile is considering implementing an emissions trading system (ETS). The government received funding from the World Bank's Project on Market Readiness (May 2014–August 2019) intended to both improve the design and implementation of the carbon tax (contributing, in part, to the carbon-pricing portion of the legislation introduced in 2018, described above) and to conduct preliminary design of a potential ETS.^{51,52}

Colombia

Colombia enacted a tax on the carbon content of fossil fuels – applicable to producers and importers of liquid fuels and natural gas used in industry – in December 2016, at approximately \$5/tCO₂, with an annual increase of 1% plus inflation (up to \$10/tCO₂). The carbon tax was included in a broad tax-reform bill, as in Chile, and became effective in January 2017.⁵³

A subsequent regulation, in mid-2017, allows firms to cover 100% of their obligations with verified domestic offsets, though use of credits decreased considerably in late 2018 and 2019

50 Lithgow, Matt. "COP24: Chile Weighs Adding Offsets as Compliance Option under Expanded CO₂ Tax." *Carbon Pulse*, December 13, 2018. <https://carbon-pulse.com/65415>; Garside, Ben. "Chile seen allowing unlimited offsets for expanded CO₂ tax, may add RECs." March 12, 2019. *Carbon Pulse*. <https://carbon-pulse.com/70849>. One anonymous interviewee saw the introduction of offsets as providing potential to incentivize renewable energy.

51 Ministry of Energy, Government of Chile. May 17, 2019. "PMR Project Implementation Status Report (ISR)." www.thepmr.org/system/files/documents/2019%20Chile%20PMR%20Project%20Implementation%20Status%20Report.pdf.

52 International Carbon Action Partnership. September 5, 2019. "Chile." Information sheet on emissions trading system. [https://icapcarbonaction.com/en/?option=com_etsmap&task=export&format=pdf&layout=list&systems\[\]=54](https://icapcarbonaction.com/en/?option=com_etsmap&task=export&format=pdf&layout=list&systems[]=54).

53 Carbon Trust, Environmental Defense Fund, and IETA. January 2018. "Colombia: An Emissions Trading Case Study." pp. 5-6. www.ieta.org/resources/Resources/Case_Studies_Worlds_Carbon_Markets/2018/Colombia-Case-Study-2018.pdf; IETA. September 2018. "Carbon Pricing Across the Americas." p. 9. https://ieta.org/resources/Resources/GHG_Report/2018/IETAInsights2018Q3_CarbonPricingintheAmericas.pdf; Ballesteros, Articus. October 10, 2017. "Colombia's Carbon Tax Shows Early Signs of Success." *Colombia Reports*. <https://colombiareports.com/colombias-carbon-tax-shows-early-signs-success>; Romero, Germán. November 2018. "Colombian Experience of Implementation Carbon Tax." Presentation at meeting of the World Bank Partnership for Market Readiness. Slide 10. www.thepmr.org/system/files/documents/German%20Ppt%20%20carbon%20tax%20colombia%20%281%29_0.pdf; Monge, Camilo. November 27, 2018. "Colombia Puts a Tax on Carbon." Conservation Finance Network. www.conservationfinancenetwork.org/2018/11/27/colombia-puts-tax-on-carbon. One knowledgeable interviewee indicated that offsets were discounted 10%, but we were not able to verify that design feature in the literature.

due to short supply and tightened verification regulations.⁵⁴ In July 2018, Colombia enacted a bill for “climate change management” that, while not mandating an allowance-trading system for GHG emissions, lays the groundwork for doing so. The cap-and-trade system would cover more sectors – possibly focused on heavy industry – than the tax. The July 2018 bill “allows payments under the existing carbon tax to be recognized as an approach for emitters to meet their compliance obligations under a potential future ETS.”⁵⁵ Congressional committees have continued to work on additional legislation that would elaborate the 2018 law; many design details remain to be specified. Policy makers and other stakeholders believe it will be several years before an ETS will be adopted.⁵⁶

As part of Colombia’s preparations for a national ETS, the Colombian department of Boyaca is to begin implementing a cap-and-trade system in October 2019 – South America’s first – in collaboration with the national Ministry of the Environment. The system is voluntary; as of September 17, 2019, nineteen firms – most in energy-intensive sectors, including brick manufacturing – have agreed to participate.⁵⁷

Argentina

Argentina passed a carbon tax on liquid fossil fuels in December 2017, which went into effect in January 2018. As with Chile and Colombia, Argentina’s carbon tax was part of a much larger and more complex tax-reform bill. The first stage of implementation of the new tax was revenue neutral (unlike Chile’s and Colombia’s carbon taxes), and covered fossil fuels subject to existing excise taxes, which were terminated. The rate was initially \$10/tCO₂ and varies quarterly with the consumer price index. Revenue is designated for various specific purposes.⁵⁸ The carbon-tax law provided for fossil fuels not subject to existing taxes – fuel oil, coke, and mineral carbon – to be taxed, beginning in January 2019, at 10% of the rate for other fuels.

54 International credits were allowed during the first few months of the carbon-tax’s operation. Szabo, Mike. September 9, 2019. “Colombia Carbon Tax-Linked Offset Cancellations Slow on Supply, Administrative Bottlenecks.” *Carbon Pulse*. <https://carbon-pulse.com/81714>.

55 World Bank. June 2019. *State and Trends of Carbon Pricing 2019*. p. 37. <https://openknowledge.worldbank.org/handle/10986/31755>.

56 International Carbon Action Partnership. September 5, 2019. “Colombia.” Information sheet on emissions trading system. https://icapcarbonaction.com/en/?option=com_etsmap&task=export&format=pdf&layout=list&systems%5B%5D=92; Lithgow, Mark. July 5, 2018. “Colombia’s ETS Planning to Take at least 3 Years – Official.” *Carbon Pulse*. <http://carbon-pulse.com/55056>.

57 Szabo, Mike. September 17, 2019. “Colombia’s Boyaca Region to launch Latin America’s first emissions trading scheme.” *Carbon Pulse*. <http://carbon-pulse.com/82265>; interview with anonymous official in Colombian government.

58 “Argentina’s Comprehensive Tax Reform: its New Carbon and Liquid Fuels Taxes.” Presentation by the Ministry of Finance. April 2018. www.thepmr.org/system/files/documents/Argentina%2018-04-11%20Tax%20reform%20-%20Carbon%20tax.pdf; World Bank. June 2019. *State and Trends of Carbon Pricing 2019*. p. 29. <https://openknowledge.worldbank.org/handle/10986/31755>; Velloso, Gustavo, et al. August 2018. “Carbon Pricing Instruments in Latin America: Latin America Carbon Pricing Forum.” Konrad Adenauer Foundation. p. 5. www.kas.de/c/document_library/get_file?uuid=23a9288a-d951-cb15-dd9f-e79464a474b0&groupId=252038.

The rate for these fuels will increase by \$1/year, reaching parity with the rate for previously-taxed fuels after ten years.

DISCUSSION

Advocates of carbon pricing in Argentina, Chile, and Colombia – the only countries in South America that have adopted pricing policies to date – have promoted carbon taxes opportunistically, in the context of broader tax reforms.⁵⁹ One Chilean interviewee described that country’s tax reform as a “window of opportunity” for introducing carbon pricing. Javier Sabogal, cabinet advisor to Colombia’s Ministry of Economy, suggested in late 2018 that a carbon tax was more attractive than some other taxes. In particular, he noted that a national sales tax had received a great deal of attention as a source of revenue. It affected nearly everyone and therefore engendered broad-based opposition. A carbon tax – with many fewer taxpayers – seemed attractive to policy makers, in comparison. Sabogal concluded, “That situation helped us to push forward the new taxes on carbon.”⁶⁰ A New York Times journalist covering the carbon tax found similarly:⁶¹

Chile’s approval of a carbon tax owes much to its positioning inside a broader tax package, experts said. At the same time that it passed the carbon tax, the Chilean government raised corporate taxes substantially, in a bid to increase revenues for education and other projects. As a result, the carbon tax raised less debate within Chile than it might have otherwise...

Iván Valencia, Coordinator of Low Carbon Development Strategy in Colombia’s Ministry of the Environment and Sustainable Development, also recently emphasized how Colombia’s carbon tax was possible in the context of broad tax reform.⁶² These carbon taxes were simply not very visible;⁶³ there is no readily apparent analogue to a “broad-based tax reform” with regard to a cap-and-trade system.

59 See also Section 4.1.2.1 above, “Northern European Carbon Taxes.”

60 Monge, Camilo. November 27, 2018. “Colombia Puts a Tax on Carbon.” Conservation Finance Network. www.conservationfinancenetwork.org/2018/11/27/colombia-puts-tax-on-carbon.

61 Galbraith, Kate. October 29, 2014. “Climate Change Concerns Push Chile to Forefront of Carbon Tax Movement.” *The New York Times*. <https://www.nytimes.com/2014/10/30/business/international/climate-change-concerns-push-chile-to-forefront-of-carbon-tax-movement.html>.

62 At a panel session, “Carbon Pricing Across the America,” at Latin America and Caribbean Climate Week, August 20, 2019.

63 An update on the tax reform bill in a financial newsletter dated July 10, 2019 does not mention the carbon tax. Francisco Sepulveda. “Chile Government Introduces Significant Changes to Tax Reform Package.” *Multinational Tax & Transfer Pricing News*. <https://mnetax.com/chile-government-introduces-significant-changes-to-tax-reform-package-34844>. Three summaries of Argentina’s bill prepared by consulting, accounting, and legal firms mentioned the carbon tax only in passing, and then used the word “fuel(s)” rather than “carbon.” <https://home.kpmg/xx/en/home/insights/2018/01/tnf-argentina-tax-reform-measures-are-enacted.html>; https://www.taxand.com/wp-content/uploads/2018/08/Argentina_Taxand_MA_guide_2018.pdf; <https://www.ey.com/gl/en/services/tax/international-tax/alert--argentine-tax-reform---a-review-of-key-provisions>.

Interviewees observed that a tax may be easier to administer than a cap-and-trade system. Chile, Colombia, and Argentina have developed relatively sophisticated fiscal authorities; a carbon tax would be only one of many taxes that they levy.⁶⁴ For related reasons, government authorities might be able to implement a tax more quickly than a cap-and-trade system with which they were unfamiliar – this last argument carrying considerable weight with fiscally-constrained governments in South America.⁶⁵

Carbon-tax rates in Argentina, Chile, and Colombia have started quite low. While a low tax rate may be, politically, the easiest way to introduce carbon pricing to industry and voters in general – and, even with a low rate, such a tax may provide significant revenue⁶⁶ – a higher rate will be needed to drive the type of behavioral and technological change necessary to reduce GHG emissions sufficiently. However, efforts to increase the tax rate would render carbon taxes more visible – even if buried within large tax reform bills. Higher rates would more likely face resistance from political and lobbying groups. In particular, carbon-intensive industries in tradable sectors, such as cement and manufacturing, could use their influence to resist a higher tax over competitiveness concerns. In Colombia, where there is considerable consensus on the need to address climate change, one interviewee nonetheless described a significantly higher carbon tax as infeasible.

Iván Valencia (see above) saw in this challenge an opening for cap and trade. As the cap is lowered, of course, allowance prices will tend to increase, but perhaps Valencia was suggesting that an allowance price is less visible than an explicit tax rate. Two interviewees variously saw cap and trade as both the preferred choice of developed-country collaborators and as a longer-term trend in Chile and Colombia. According to them, an important advantage of cap and trade is the ability to build political support through free distribution of some allowances.⁶⁷ This would be particularly important to sectors more likely to face competitiveness pressures.⁶⁸ Other sources considered the potential for both mechanisms to be in place simultaneously, as will likely be the case in Colombia. They suggested that a cap-and-trade system is best for

⁶⁴ See also Section 2.2.7 above, “Complexity and Administration.”

⁶⁵ Rodrigo Pizarro, economist in UN ECLAC, remarks at panel session, “Carbon Pricing Across the America,” at Latin America and Caribbean Climate Week, August 20, 2019.

⁶⁶ An anonymous interviewee in Chile’s government felt that the revenue from the carbon tax was currently more important than any impact on emissions. Mexico’s carbon tax also generated a significant amount of revenue relatively quickly. As noted above, the first phase of Argentina’s carbon-tax system is revenue neutral.

⁶⁷ See Section 3.2.2. “Political Supply,” above. There it is noted that the free allocation of allowances can be mimicked by providing tax exemptions. One interviewee in Chile explicitly stated, however, that a cap-and-trade system offered more flexibility in this regard.

⁶⁸ Though this is a common perception, free allocation of allowances that is not keyed to previous output levels does not typically affect marginal costs of production faced by firms and therefore does not, in fact, alleviate competitive disadvantage that might be imposed by the cap-and-trade system. See various sections above. One interviewee noted, as well, that free distribution can create political tension if not implemented in what stakeholders perceive to be a fair manner.

industrial sources; large firms have the administrative resources to accurately characterize their marginal costs and to conduct trading. For other sectors with fewer administrative resources, a tax may be more desirable.

Cap-and-trade systems are vulnerable to market concentration – for example, in the power sector in Chile. While linkage (“regional integration”) may alleviate price volatility arising in part from market concentration (and in part from small markets), one Colombian interviewee was skeptical about South American governments being able to implement linkage in the short term.

Use of offsets may reduce firms’ cost of compliance, and in all three countries’ carbon-tax systems, offsets are either in use or in the process of implementation. Tax revenues themselves cannot be earmarked for specific expenditures under Chilean law, but payments for offset credits could support renewable energy and other projects perceived to reduce emissions. Unlike in Chile, Colombian tax revenues can be earmarked, and carbon tax revenues have been directed toward sustainable development and peacebuilding activities in rural areas previously occupied by the FARC.⁶⁹ More generally, political opposition to higher tax rates might be alleviated by directing revenues to popular uses – either directly or through offset-credit systems.

Industrial stakeholders themselves have views on carbon pricing somewhat similar to those found in other countries. The power sector in both Chile and Colombia is neutral with regard to choice of policy instrument – cap and trade or a carbon tax. In either case, it sees potential for growth as a result of electrification of transportation, space heating, and, perhaps, other liquid-fuel-based activities, as a result of policies that reduce GHG emissions. Industry and mining are more supportive of cap and trade, believing that system is better able to address their competitiveness concerns through free allocation of allowances.

In conclusion, certain countries in South America have made considerable progress with carbon-pricing policy, primarily, at this time, with carbon taxes. There are ongoing debates in these – and other – jurisdictions regarding the relative merits of carbon taxes and cap-and-trade systems. It is hoped that the body of this paper might prove useful in resolving these debates, with the understanding that the choice of policy instrument will differ among countries, depending on economic, political, and other factors.

⁶⁹ FARC is the acronym for the Revolutionary Armed Forces of Colombia – People’s Army, with which the Colombian government was at war from the mid-1960s through 2017.

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