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The Relationship Between Policy Design Choices, Carbon Prices, and Ambition: Evidence from the Field

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Abstract: As carbon pricing draws increased attention as a policy mechanism to address climate change, stakeholders may consider ambition – defined here as the reduction in emissions compared to business-as-usual (BAU) – as an important policy goal. Understanding how policy design affects ambition, particularly the choice between a carbon tax or cap-and-trade mechanism, however, can be a challenge. Emissions reductions compared to BAU are difficult to measure and can be attributed to a variety of other factors unrelated to the carbon pricing policy itself. In this paper, we discuss how the carbon price level may serve as a proxy for ambition when direct measures of emission reduction below BAU are elusive, and how other design choices can also contribute to policy ambition. Using data on twenty-six carbon pricing policies implemented worldwide since 1990, we present several assertions about the relationship between carbon price, design choices, and policy ambition. Specifically, we discuss whether carbon taxes or cap-and-trade policies tend to exhibit more features of ambitious carbon reduction policies, and how factors including sectoral coverage, companion policies, offsets, and revenue use interact with carbon price to raise or lower ambition. We find that carbon tax programs tend to have higher carbon prices than cap-and-trade policies. We do not find evidence that lower prices in cap-and-trade systems occur as a result of greater sectoral coverage or more companion GHG reduction policies, factors which might raise overall ambition but produce lower price levels.

Policy Insights:

- Carbon price can be a useful proxy for measuring policy ambition, but various design choices affect the relationship between carbon price and policy ambition.
- Jurisdictions that have implemented a carbon tax appear to have more ambitious policies considering price and emissions coverage alone.
- The use of companion policies is prevalent under both types of policies, but such policies only contribute to greater ambition under carbon tax policies.
- Offsets arise almost exclusively under cap-and-trade and could contribute to lower prices vis-à-vis carbon taxes.
- With mixed evidence to link instrument choice and ambition, the more important question may be the impact of policy choices on political acceptability.

Keywords: carbon pricing; carbon tax; cap-and-trade; policy ambition

Introduction

Pricing carbon as a way to reduce greenhouse gas (GHG) emissions has become a favored solution among economists and policymakers to address climate change over the past thirty years. By using market mechanisms, jurisdictions can make emitting carbon dioxide (CO_2) and other GHGs more expensive for firms and other entities, incentivizing them to emit less. As opposed to command-and-control regulations that prescribe certain actions or source-specific outcomes, carbon prices provide greater flexibility for entities to choose whether, how, and how much they reduce their emissions, leading to the lowest-cost emissions reductions. Carbon pricing systems often have the added benefit of generating significant revenue (Aldy & Pizer, 2009) and sending a clear price signal to incentivize clean technology development (Parry, Veung, & Heine, 2015).

The United States has a history of fits and starts with carbon pricing. The U.S. Congress has introduced several pieces of legislation to create a nationwide GHG cap-and-trade program over the past decade, but the efforts have failed to become law. In lieu of Congressional action, the Obama Administration sought to regulate GHGs through the Clean Air Act, leading to the *Clean Power Plan* designed to reduce GHGs from the electric power sector (US EPA, 2015). This policy would have potentially expanded the use of carbon pricing as states faced various choices to implement the emissions reductions requirements, including the ability to adopt emissions trading within the states or in concert with other states. Upon entering office in early 2017, however, the Trump Administration essentially reversed the Obama rules on carbon emissions regulation and the expanded market price that would have gone with it (US EPA, 2017).

At the state level, carbon pricing exists for the electric power sector in nine northeastern U.S. states (the Regional Greenhouse Gas Initiative, or RGGI) and across most emitting sectors in California. Both regions have committed to continuing these programs and even finding trading partners despite the expectation of little interest in carbon pricing at the federal level for the time being. In its 2017 extension, the RGGI program announced a 2030 cap that is 65% below its 2009 cap. There has also been movement to expand the RGGI program to include two more states, New Jersey and Virginia (New Jersey was formerly part of RGGI until 2013). California recently passed legislation to extend its program through 2030 (ICAP, 2018).

Due in part to the success of these state-level initiatives, carbon pricing options are receiving renewed attention in the United States. Several states such as Washington, Massachusetts, Oregon and others are exploring the possibility of a carbon tax to limit greenhouse gas emissions. At the national level, organizations including Citizen's Climate Lobby and the Congressional Climate Solutions Caucus are pursuing bipartisan climate solutions in the form of a national carbon pricing scheme (Temple, 2017). In July 2018, U.S. Representative Carlos Curbelo (R-FL) introduced a bill to establish a national carbon tax (Colman & Sobcyzk, 2018). While the political prospects of such a bill are debatable, the introduction of a carbon tax proposal by a House Republican in 2018 is notable.

There is a growing interest in designing policies that are both cost-effective and ambitious in terms of potential to reduce GHG emissions. Specifically, the choice of policy instrument to price carbon – whether to choose a carbon tax or a cap-and-trade scheme – is an important part of this national climate policy dialogue. While many previous studies on climate policy design have explored how each policy instrument contributes to the overall cost-effectiveness of the policy (e.g. Aldy & Pizer, 2009; Goulder & Parry, 2008; Goulder & Schein, 2013; Weitzman, 1974; Weyant, 1993), fewer have investigated how instrument choice relates to *policy ambition*, defined here as the reduction of realized emissions below business-as-usual emission projections.

This study discusses the various factors that contribute to policy ambition using real-world evidence. Previously, much of the research on designing ambitious carbon pricing policies has focused on ex-ante analyses of "optimal design", without connection to a real proposed or implemented policy. However, with more than 25 years of experience with carbon pricing policies around the world, there is now much to learn from an ex-post analysis of the factors that have contributed to ambition in the policies implemented thus far. Choices that policymakers make when designing carbon pricing policies can directly influence how effective the policy is at reducing emissions. Therefore, the focus of this analysis is on understanding how design choices made in policies around the world might affect and reflect ambition.

In the following sections, we first expand on the concept of policy ambition and discuss how one feature of policies – the carbon price itself – can be a useful proxy to measure ambition. While carbon price is a theoretical proxy for ambition, other policy design choices can also interact with the relationship between carbon price and policy ambition. Given this, we then present several assertions about how we expect policy design to affect ambition, and examine these assertions using evidence from previously implemented carbon pricing policies around the world.

Carbon Price as a Measure of Policy Ambition

Above we suggest an ideal definition of policy ambition as actual emissions reduced below business-as-usual (BAU), but this can be a problematic measure for practical reasons. Transparent ex-post measurements of emissions reductions versus BAU in all jurisdictions is challenging using available data as it requires modeling counter-factual outcomes (although some researchers have attempted this, e.g. Bruvoll & Larsen, 2004; Haites et al., 2018; Murray & Maniloff, 2015; Nadal, 2016). An alternative is to examine absolute changes over time—are emissions declining against history? From a theoretical perspective, however, emissions reductions against history do not always signal an ambitious climate change policy. Major macroeconomic shocks, such as the fall of the Soviet Union in the 1990s, or technological shifts, such as the U.S. shale gas boom in the mid-2000's, can result in emissions reductions that have nothing to do with an ambitious climate change policy (York, 2008). For these reasons, rather than quantified emission reductions measured against BAU or history, a possible proxy for policy ambition is the carbon price level itself.

A carbon price offers a useful metric for comparing policy ambition because it is a direct measure of the marginal cost of emission reductions. Under a standard assumption of marginal cost curves rising with the scale of production, the higher the marginal cost, the higher the volume of production – in this case, emission reductions. Hence prices may be a good way to compare policy ambition across jurisdictions, as the price should directly influence emissions reductions under a carbon pricing policy (Aldy & Pizer, 2016). Moreover, analysts can directly measure price and compare them between jurisdictions over time.[1] Prices also act as a signal to create long-run incentives for emissions reductions in a jurisdiction: the higher they are the stronger (i.e., more ambitious) the incentive to invest in low-emission technologies. High prices

[1] We note that in some cases, fiscal cushioning – cutting other energy taxes as a carbon tax (or cap-and-trade) is introduced – can reduce the link between carbon prices and emissions reductions (Rohling & Ohndorf, 2012). However, this approach is not common in practice and therefore is of little practical relevance here.

can theoretically arise from either a carbon tax or a cap-and-trade policy, thereby enabling ambition comparisons between programs operating under either mechanism.

The choice of a policy target (tax rate under a carbon tax and emissions cap under a cap-and-trade system) and its trajectory over time is a result of several considerations. From an economist's perspective, the target tax rate (which defines the price) should be set to match the marginal harm from emissions – namely, the intersection of the marginal cost and marginal benefit curves of abatement (Pigou, 1932; Weitzman, 1974). However, most carbon prices fall below this economically optimal rate for political reasons. While higher prices signal more policy ambition, they may also lead to costs that are politically unsustainable or that harm firms exposed to international trade (Goulder, Hafstead, & Dworsky, 2010). These risks may lead governments to lower the carbon price to increase political acceptability.

Under either approach, an ambitious carbon policy typically includes a price trajectory that may start relatively low but increases over time– either specified in the tax mechanism or as the result of a progressively more stringent emissions cap causing the associated emission allowances to be more scarce and command a higher price. Designing a price or cap trajectory that starts relatively low and increases over time has the added benefit of increasing initial political palatability. This allows covered entities to ease into the emissions reduction market while also enabling jurisdictions to increase their ambition over time and respond to new information that emerges about the costs and benefits of reducing emissions (Aldy, 2017; Metcalf & Weisbach, 2009).

Carbon prices, therefore, can be a helpful way to evaluate the ambition of a carbon pricing policy: a high price signals high policy ambition. However, various other design choices in the policy package, such as the sectoral scope of policy coverage, the use of companion GHG reduction policies in addition to carbon pricing, the use of emission offset credits, and the use of revenue collected by the government can alter the expected relationship between higher carbon price levels and higher volumes of emissions reduced. In the following section we present several principled assertions about how other design choices may also affect ambition and examine these assertions based on evidence from policies implemented to date.

Assertions about the Impact of Policy Design Choices on Price and Ambition

When designing a carbon pricing policy, policymakers must consider several structural choices that can influence overall policy ambition. In this section, we present five assertions about how policy design might affect ambition under carbon taxes and cap-and-trade policies, based on relevant principles of how markets and institutions should work in practice. Using evidence from implemented policies, we discuss whether experience with carbon pricing supports, refutes, or remains inconclusive regarding these assertions.

As of 2017, 46 national and subnational jurisdictions have implemented a carbon pricing policy (23 cap-and-trade programs and 23 carbon tax programs), covering 15% of global greenhouse gas emissions (World Bank Group & Ecofys, 2017). Table 1 summarizes the carbon tax policies and Table 2 summarizes the cap-and-trade policies implemented around the world between 1990 and 2014. We limit the dataset to policies implemented in 2014 or earlier to allow for adequate time to have passed to draw conclusions regarding policy ambition and durability. We report data on each based on the design factors that can affect policy ambition and draw conclusions about the policy ambition of carbon tax and cap-and-trade policies.

An important caveat is that none of this evidence should be viewed as unequivocal. Here we simply explore possible associations among carbon prices, design choices, and policy ambition. This is not a randomized experiment in which some jurisdictions were randomly assigned carbon taxes and other cap-and-trade, and then outcomes compared. Some jurisdictions may start with higher or lower intended ambition leading toward the choice of one instrument over the other. Alternatively, there might be other underlying factors that introduce an observed association between instrument choice and ambition that are difficult to unpack. Here we simply present evidence based on observable features of each policy, and discuss how it supports or refutes the assertions.

Assertion 1: Instrument choice may be independent of ambition: Both cap-and-trade and carbon tax policies can achieve equally high carbon prices.

For policymakers whose goal is to design an ambitious carbon pricing policy, a primary decision is the type of instrument – whether to use a price-based carbon tax or quantity-based cap-and-trade policy. A carbon tax is a fixed assessment per unit of emissions typically collected (and often redistributed) by the government. Under a carbon tax, price levels are set directly through a levy on either the carbon content of a fuel or the greenhouse gas emissions released when a fossil fuel is burned. By establishing a set price, a carbon tax can be an effective way to encourage mitigation while avoiding uncertainty over compliance costs associated with the price of carbon. However, because the policy is based on price and not quantity, the resulting emission level (and reduction below BAU) is uncertain.

In a cap-and-trade program, the government sets a program-wide emissions limit (or cap). The government then issues allowances commensurate with that limit, establishes a legal obligation for regulated parties to surrender one allowance for each ton of emissions, and allows those parties (and possibly others) to buy and sell allowances. Since the policy does not directly set the price level, which is instead subject to market forces, the price is variable and more vulnerable to changes in the market. However, cap-and-trade programs offer more certainty about the emission level than does a carbon tax.[2]

In principle, both carbon tax and cap-and-trade programs can be designed to achieve a high carbon price by setting an ambitious emissions target and/or a rapidly increasing price trajectory. However, it is unclear whether both instruments equally achieve ambitious price levels in practice. To explore this, we contrasted the 2017[3] median price of one ton of CO_2 equivalent (tCO_2e) among the carbon tax and cap-and-trade programs presented in Tables 1 and 2 (World Bank Group & Ecofys, 2017). For schemes that have variable prices across sources (like Norway, Finland and Mexico, see below), we used a straight average of the carbon prices (a weighted average based on percent of emissions was unavailable for all jurisdictions).

On the one hand, we see multiple examples of $10-20 per ton prices for both instruments. On the other hand, median prices are higher among carbon taxes than cap-and-trade. A comparison shows that the median carbon price under carbon tax schemes is $24/$tCO_2e$ (with a maximum of $140 in Sweden and a minimum of <$1 Mexico) while under cap-and-trade schemes the median price is $8/$tCO_2e$ (with a maximum of $14 in California and Quebec and a minimum of $2 in Kazakhstan).

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[2] Recently, certain design features have emerged in recent years to create “hybrid” approaches, which may offer better welfare outcomes and forge important political compromises than traditional tax or cap-and-trade programs (Fell, Burtraw, Morgenstern, & Palmer, 2012; Murray, Newell, & Pizer, 2009; Murray, Pizer, & Reichert, 2017). However in this analysis we refer primarily to traditional carbon tax and cap-and-trade policies.

[3] Or the most recent price for discontinued schemes

This field experience suggests that prices in the $10-$20 range *could* be achievable under either carbon tax and cap-and-trade policies, but that consistently higher prices are more common with carbon taxes. Of course, the operative question is whether these price differences reflect differences in ambition or occur alongside other differences in programmatic features that achieve ambition in other ways not reflected in the price. We discuss this further with the remaining assertions.

Assertion 2: Broad sectoral coverage can make up for a low carbon price to determine policy ambition.

Under a carbon tax system, coverage is generally determined by specifying the fuels that are subject to the tax - typically coal, liquid fuel, and natural gas. While most carbon taxes maintain a single tax rate per ton of carbon dioxide for all covered entities and fuels, some have taken a more customized approach by specifying higher or lower rates for certain fuels and sectors. Finland, Sweden and Norway, for example, offer lower tax rates to certain sectors or fuels that are exposed to competitiveness concerns, and higher rates on fuels that offer significant potential for emissions reductions without sacrificing competitiveness (Sumner, Bird, & Dobos, 2011).

As opposed to covering certain fuels, cap-and-trade programs tend to specify the sectors that will be covered under the scheme. The four primary sectors that use fossil fuels are electric power generation, other industrial production, transportation, and buildings (both commercial and residential), which can be further subdivided in many ways (Metcalf & Weisbach, 2009). Other sectors that generate emissions and are sometimes covered by carbon pricing policies include agriculture, forestry/land use, waste and landfills, cement production, and other industrial processes that emit non-CO2 gases such as chlorofluorocarbons.

The ambition of a high carbon price diminishes when it applies to a limited segment of the economy. In general, we find that the carbon prices under tax schemes tend to apply to *more sectors* than do the prices under cap-and-trade schemes. This is due in part to the fact that carbon taxes target the actual fuel (coal, natural gas, petrol, etc.) not the smokestack emissions. This affects all sectors of the economy and is less easily restricted to a subset of sectors. Meanwhile under cap-and-trade programs, the policies tend to specify the sectors of the economy whose regulated sources must comply by having emissions allowances (or offset credits) that match their emissions.

However, cap-and-trade programs more universally cover the electricity and industry sectors that contribute significantly to jurisdiction emissions. Noticeably, the carbon tax programs with the highest prices (Finland, Sweden and Norway) do not cover either the electricity or the industrial sectors (those are covered by the EU ETS in those regions). This suggests that the highest prices are perhaps more common in policies with more narrow coverage, confounding the relationship between price and policy ambition.

While sectoral coverage is one proxy for breadth of the carbon pricing policy, it is perhaps more meaningful to consider the *percentage of overall jurisdiction emissions* that are covered by the policy. While carbon prices tend to be lower in cap-and-trade programs, they cover a larger percentage of total jurisdictional emissions than do carbon taxes, due in large part to their consistent coverage of the electricity and industry sectors. The average percent of total jurisdiction emissions covered under a carbon tax is 37%, compared to 46% under cap-and-trade schemes (World Bank Group & Ecofys, 2017).

One should also consider that several of the carbon pricing policies are complementary to each other within the same jurisdiction, with a carbon tax and a cap-and-trade policy covering different sectors of the economy, or sometimes overlapping (as is the case with Ireland and the EU ETS). For example, the purpose of several of the carbon tax policies in Europe was to cover non- ETS sectors, such as motor fuels. If we only consider jurisdictions that have one system but not both in this analysis, we find that the average economy-wide emissions coverage is similar under both systems: 50% under carbon tax policies, and 47% under cap-and-trade policies. This suggests that, ultimately, there is little evidence of a systematic difference in scope between cap-and-trade and carbon taxes, and therefore scope differences are unlikely to mitigate price differences between the policy instruments.

Assertion 3: Companion policies should lower carbon prices under a cap-and-trade system, other things equal, but not under a carbon tax policy.

The existence of companion policies (other policies in the same jurisdiction that also lower emissions) can interact with the price and overall ambition of a carbon pricing policy. Companion policies come in many forms, including energy efficiency mandates, support for renewable energy deployment (or mandated use of renewable energy), investment in research and design of low-carbon technologies, and the direct regulation of GHG co-pollutants, for example. These policies can also be used to create co-benefits in addition to GHG reductions (reduction in other air pollutants, diversifying the energy supply) (Diamant, 2013).[4]

We can classify companion policies by their timing and/or motivation. Some are pre-existing policies implemented prior to the carbon price and remain in place as the carbon price

[4] Companion policies can also target emission reductions in sectors in which it is difficult to implement a pricing mechanism. However, our focus here is companion policies that overlap with carbon pricing.

takes effect. In other cases, the policies are complementary, in that they are introduced as a package with the carbon price as an ex-ante “hedge” to ensure emissions reductions occur (Burtraw, Keyes, & Zetterberg, 2018). If a carbon price itself is perceived as too low to induce ambitious reductions (at least initially), jurisdictions may include other policies to increase ambition or to address market failures such as underinvestment in research and development and common use infrastructure, information asymmetries, or excess market power (Denniss, Grudnoff, & Macintosh, 2012).

Jurisdictions may also use companion policies when they prefer not to lean too heavily on the carbon price for emissions reductions. Given the urgency of climate change, some jurisdictions may feel that they need to take a portfolio approach and pass a range of policies. In Japan, for example, the carbon tax has been implemented primarily as a way to raise revenue to fund the companion emissions-reduction policies, such as policies to promote energy conservation, renewable energy, distributed generation, and investment in innovating technologies (Hood, 2013). In other instances, companion policies such as energy efficiency standards can address instances where the actors paying the carbon price are not the ones making the decisions about emissions reductions, suggesting minimal mitigation incentive. This can occur, for example, when tenants pay the carbon price passed on through electricity bills, but property owners make the decision about energy-saving investments.[5] Energy efficiency mandates can provide property owners with the impetus to undertake efficiency improvements that the pricing system would not otherwise incentivize.

[5] This is referred to as the “split incentives” problem, further compounded by market failures that may limit the ability of the landlord to charge more for rental units that cost more to build but use less energy.

No matter the intention of the policies, the effect of companion policies on policy ambition is likely to be different under a carbon tax than under cap-and trade policies. Under a carbon tax, companion policies should generate *additional* emissions reductions without necessarily affecting the incentives created by the carbon price, which is fixed. However, under cap-and-trade schemes, the use of companion policies in the same sectors as the cap will not directly lead to additional reductions since the emissions cap is fixed. By forcing emissions to drop with activities generated by the companion policies, this frees up allowances to be used by other emission sources under the cap. This could lower the market price and reduce the incentive for those other sources to reduce emissions. In either case, companion policies can undermine the cost-effectiveness of the pricing policy by requiring more expensive mitigation in the arenas affected by the companion policy than would be supported by carbon pricing alone (Diamant, 2013; Goulder & Schein, 2013; Goulder & Stavins, 2012).

While companion policies may not directly increase ambition under a cap-and-trade policy, they could indirectly increase ambition by influencing political support for the policy. If the policy environment is such that political resistance increases with higher carbon prices, companion policies may have an indirect effect on future iterations of the cap level. If companion policies lead to a lower carbon price, that may reduce political resistance and encourage a more ambitious emissions cap in the future. Absent those policies and facing higher carbon prices, future policies may face greater political opposition and might be less ambitious. Companion policies could also increase ambition if they spur innovation and/or scale economies that reduces costs. For example, companion policies focused on solar energy have arguably had a sizeable impact on costs in the last half decade and are predicted to continue to lower the costs of renewable deployment (IRENA, 2016).

As depicted in Tables 1 and 2, the use of companion policies is common in both carbon tax and cap-and-trade schemes. We classify companion policies into six categories: energy efficiency policies (such as energy efficient building standards); clean energy deployment (generally the government support or mandatory use of a certain amount of clean energy, including renewable portfolio standards, renewable fuel standards, subsidies for clean energy vehicles); public investment in clean energy technology research and development; other, non-carbon related taxes on fossil fuel energy (such as fuel taxes); pollutant regulation (such as performance standards for vehicle or stationary source emissions); and the use of a cap-and-trade system or carbon tax in conjunction with each other. We only note companion policies that apply to sectors that are also covered by the carbon pricing policy, since they are most relevant for our discussion of ambition and pricing. The most commonly used companion policies in both types of schemes are energy efficiency regulations and clean energy deployment.

Given the varying nature of companion policies, and the fact that these policies create significant uncertainty in emissions levels and prices, it is difficult to draw many conclusions about their influence on policy ambition from these tables. The use of two companion policies in the European Union– the Energy Efficiency and Renewable Energy Directives – have been asserted to depress overall prices in the EU ETS. A 2015 analysis by the International Emissions Trading Association argues that these two policies, which require member states to implement energy efficiency and renewable energy policies to lower emissions on top of the EU ETS, will lead to a substantial reduction in demand for ETS allowances and a lower allowance price without any further adjustments to the cap (at least through 2020) (IETA, 2015). Similarly, an analysis of the effect of companion policies in the California ETS found that they compromised the vast majority of emission reductions and depressed prices (Borenstein, Bushnell, Wolak, & Zaragoza-Watkins, 2015).

One particularly interesting interaction is the overlap between domestic carbon taxes and some parts of the EU ETS. Like other companion policies, this causes an inconsistent price signal and encourages more expensive reductions in some jurisdictions and sectors all within the ETS (IETA, 2015). For example, the UK has instituted a price floor that raises the carbon price paid by the UK electricity sector above that which might emerge from the EU ETS if the EU ETS price is below the UK floor. Thus, any reductions gained by the UK price floor may just free up allowances under the EU cap to be used by other emitters, leading to no net reductions across the EU. Thus, it would be somewhat misleading to call the UK price floor a more ambitious policy than the ETS, even with a higher price, if emissions remain the same.

Assertion 4: Offsets will lower carbon prices under a cap-and-trade system, other things equal, but not under a tax.

Another design choice that can impact policy ambition is the use of offsets. Often, carbon pricing policies build in flexibility by allowing firms to purchase offsets to account for a certain amount of emissions that would otherwise face an allowance requirement, and in some cases, in lieu of paying the carbon tax. Rather than buying allowances or paying the tax, a covered entity can purchase emissions reduction credits created by an entity not covered by the scheme (often outside of the jurisdiction). Allowing entities to use offsets can be an important tool to lower the cost of compliance and increase both short-term cost-effectiveness and long-term technology innovation (Ellerman, Convery, & de Perthuis, 2010; Stavins, 2008). However, many scholars have also raised concerns about additionality, the extent to which the emission reductions credited by the offsets would have occurred anyway (Wara & Victor, 2008). Allowing significant offsets, therefore, could reduce the ambition of a carbon pricing policy, even if the price remains high.

Because carbon offsets have generally been incorporated in cap-and-trade schemes and not carbon taxes,[6] the comparative nature of this assertion with regard to taxes is more a matter of theory than one informed by evidence. Experience does allow us to consider the effect of offsets on observed cap-and-trade prices, however. Allowing the use of offsets in a cap-and-trade system should decrease demand for emissions allowances within the capped sectors, therefore driving down the allowance price. A 2013 modeled estimate of emissions prices in 2020 by California's Air Resources Board estimated that in a policy scenario that allowed the use of offsets, the carbon price would be five times lower than a scenario that did not allow offsets (Diamant, 2013). This analysis was an ex ante study performed before the cap-and-trade program was implemented; no ex post studies (to our knowledge) have confirmed this estimate. However, in the EU ETS system, the use of offsets from the Clean Development Mechanism to meet emissions reduction targets has, according to some ex post analyses, contributed to low prices in the EU (Ellerman et al., 2010; Green, 2017). New Zealand also experienced an oversupply of emissions credits when the price of international credits under the Kyoto system plummeted, leading to a decline in domestic carbon price (Leining & Kerr, 2016).

Under a carbon tax, allowing the limited use of offsets would simply lower effective tax payments but should not affect emissions at regulated firms. That is, rather than paying the tax

[6] A proposed carbon tax in South Africa would incorporate carbon offsets into its structure, allowing covered entities to avoid paying the tax on 5-10% of their emissions (based on sector) by purchasing domestic carbon offsets at a lower price (South Africa Minister of Finance, 2017). This effectively increases the emission reductions associated with the tax, without driving down the carbon price.

on some of their emissions, they would choose lower cost offsets as a carbon tax credit. So long as all firms are still paying the full tax rate on the remaining emissions, and reduce those tax payments when they mitigate, the incentive remains the same. Under both instrument choices, there is always concern about whether offsets are additional to what would have been achieved anyway. This is a larger issue for cap-and-trade, where failure to achieve additionality implies that emissions exceed the established cap.

With these validity and price suppression concerns in mind, most of the cap-and-trade schemes included in Table 2 have put qualitative and quantitative limits on offsets. With a few exceptions (EU ETS, Norway ETS, Switzerland ETS and Tokyo ETS), most programs limit their offsets to domestic sources. Furthermore, subnational programs (e.g, California and Quebec) require that a certain proportion of offsets come from inside the covered jurisdiction itself, mitigating concerns of additionality. These geographic restrictions may build political support as many of the co-benefits of emissions reductions (such as pollutant reduction or clean energy investment) stay within the jurisdiction or sector. California's most recent update, for example, specifies that at least half of offset credits must provide direct environmental benefit to the state (ICAP, 2018).

The quantitative limit on offsets ranges from 3.3% of total emissions (RGGI) to no limit (Kazakhstan), but most allow entities to offset around 10% of their total emissions liability. However, restrictions on the use of offsets does not seem to, by itself, associate with a lower carbon price. Cap-and-trade programs with the highest prices are not the same as those with the most stringent restrictions on offsets. However, the restriction of many of the highest-price programs to domestic offsets may signal a commitment to ambitious emissions reductions within the jurisdiction. Additionally, several programs, including California and New Zealand, have also begun to lower the allowed share of offsets that can be used to meet emission targets, denoting another example of how trajectories can become more ambitious over time (ICAP, 2018).

Ultimately, our observations about offsets and ambition tend to mirror those regarding companion policies. Lower observed cap-and-trade prices might reflect the price-depressing effect of either companion policies or offsets. Alternatively, they might be linked to more ambitious caps now or in the future. At the same time, offsets are different. They promise lower costs, not higher costs, under cap-and-trade but pose an additional risk if offsets are not additional to other emissions reductions.

Assertion 5: Revenue use can increase ambition if used to encourage further emissions reductions or broaden political support

One important motivation for the implementation of a carbon pricing policy is the ability to generate revenue. Jurisdictions have historically made three choices about revenue use from a carbon pricing scheme (Carl & Fedor, 2016). One use of revenues is to fund investment in renewable energy projects, technology development, or other emissions reductions efforts ("green spending"). Some jurisdictions choose to deposit the revenue into a general governmental fund and spend it on other priorities unrelated to climate change ("general fund"). Third, policies may return revenue to the economy in the form of dividend payments or non-environmental tax cuts ("revenue recycling"). Jurisdictions may also choose to use a combination of these strategies.

While revenue generation is more common under carbon tax policies (since many cap-and-trade policies allocate emissions allowances freely), it can affect policy ambition under either policy in two ways. First, if the revenue is recycled or used to reduce other burdensome taxes, this can contribute to the political viability and longevity of a carbon pricing policy (particularly if this feature is well-communicated) (Murray and Rivers, 2015). Moreover, by lowering taxes in other areas, this strategy increases the potential durability of the carbon price, as those other taxes would be more difficult to raise if the revenue from the carbon price disappeared.

Second, using the revenues to re-invest in clean energy technologies or other methods to reduce emissions may increase the ambition of the policy more directly. By investing in infrastructure and technologies to make emissions reductions more cost-effective, this type of revenue use could generate additional emissions reductions, beyond those achieved through the carbon price itself. This approach may be more popular among certain segments of the population most interested in aggressive emissions reductions policies, or those likely to be the recipients of such funds (Jenkins, 2014).

Revenue streams from a carbon tax are likely to be more predictable than those from a cap-and-trade allowance auction because the revenue certainty attained by a fixed price (and varying emissions) is generally much higher than the revenue certainty attained by a fixed emissions quantity (and varying price). If governments plan to use revenues from a carbon pricing scheme as a government revenue source (to either replace a current revenue source or contribute to the general fund), this revenue certainty could be an important concern.

Reflecting on the existing schemes, we would expect to see carbon taxes used more frequently than cap-and-trade systems when the revenue is used to reduce other taxes (when funding certainty is more important). We would also expect that using revenues either to reduce other taxes or on green spending would increase ambition more than channeling it into government funds. On average, both types of policies send the plurality of their revenue into government funds, although the average percentage of revenues funneled into government funds is slightly lower among carbon taxes (43% among carbon taxes and 50% among cap-and-trade). While a slightly larger average percentage of funds are spent on green spending under cap-and-trade programs (32% compared to 23% among carbon taxes), we observe a significantly greater percentage of revenues used for revenue recycling among carbon taxes (31%, compared to 7% among cap-and-trade). (Carl & Fedor, 2016). As discussed, using revenues for revenue recycling may build broader political support and contribute to policy durability and therefore increased ambition. Meanwhile, reinvesting revenues into emissions reductions through green spending may do less to build political support, but can increase overall emissions reductions, although the risks associated with companion policies under cap-and-trade schemes persist.

Conclusions

In this paper we have examined the relationship between carbon price, policy design choices, and ambition. All else equal, carbon pricing is more ambitious the more it drives emission reductions (departure from BAU). However, since BAU is practically difficult to measure, we explore price as a proxy for ambition of the carbon pricing policy component to see if this reveals insights. While price can be a helpful metric to measure policy ambition, other design choices interact with price to impact ambition. Specifically, we discuss how target trajectories, sectoral coverage, companion policies, offsets, and revenue use also affect ambition.

Based on a review of existing policies, we draw some conclusions about policy design and ambition. First, we find that carbon tax policies have had higher median prices than cap-and-trade policies with similar emissions coverage, suggesting that jurisdictions might attain greater ambition through a carbon tax than a cap-and-trade policy. There is some evidence that carbon taxes apply to a smaller share of emissions, but this difference disappears when we eliminate jurisdictions using both instruments. We find similar prevalence of companion policies in both carbon tax and cap-and-trade policies, but such policies only increase ambition under carbon tax policies. While offsets are almost entirely associated with cap-and-trade programs, they can increase cost-effectiveness and compliance flexibility for covered entities. Like companion policies, their use under cap-and-trade may depress carbon prices. However, as long as offsets are additional, this does not reduce ambition and may make up for lower overall prices.

Finally, the use of revenue can be an important consideration in policy ambition. Green spending could contribute additional reductions in greenhouse gases (increasing overall ambition), while revenue recycling could increase political support and therefore increase the likelihood that a policy will both pass and persist. On average, most of the revenue from both carbon taxes and cap-and-trade programs goes into general funds, with little impact on ambition. However, carbon taxes use revenue recycling more frequently than cap-and-trade programs do, which can build greater political support and increase ambition in the long-run.

While these policy design considerations are important for policy ambition, no carbon pricing scheme can reduce emissions if it is not adopted to begin with or sustained over time. As such, the political acceptability of a policy's design and execution is a feature that is critical to its initiation and sustained success (Baranzini et al., 2017; Webber, 1986). One under-explored issue that should be the focus of further research is the connection between policy design, political acceptability and ambition. In a U.S. political environment that is already highly divided regarding climate change policy (Egan & Mullin, 2017), attention to factors that impact political viability of a pricing scheme is vital. Policies can achieve nothing if they are not passed, and passage requires balancing potential competing interests of the body politic. Instrument choice may be as much or more related to the political preferences of the adopting jurisdiction for certain characteristics of one pricing approach over the other (e.g., precautionary principle, revenue predictability for fiscal purposes, ease of implementation, etc.) than to the notion that one is more systematically ambitious than the other. While this analysis considers how some design features may impact political favorability, this is an important feature of policy ambition that should be explored further in future research.

Table 1: Carbon Taxes Implemented by 2014

				Sectors Covered							Fuels Covered			Revenue Use			Companion Policies					
Jurisdiction	**Year Implemented**	**Emissions Coverage**	**2017 Price (tCO_2e)**	**Electricity**	**Industry**	**Buildings (Heating)**	**Transportation**	**Aviation**	**Waste**	**Agriculture/Forestry**	**Coal**	**Natural Gas**	**Gasoline/Diesel Fuel**	**Green Spending**	**General Funds**	**Revenue Recycling**	**Energy Efficiency**	**Clean Energy Deployment**	**R&D Investment**	**Other Energy/ Fuel Taxes**	**Pollutant Regulation**	**ETS**
Finland	1990	15%	$69-$73			■	■				■		■	0%	50%	50%	■	■		■		■
Sweden	1991	25%	$140			■	■			■	■	■	■	0%	50%	50%	■	■	■	■		■
Norway	1991	50%	$4-$56			■	■	■				■	■	30%	40%	30%	■	■		■		■
Denmark	1992	45%	$27	■	■	■	■		■		■	■	■	8%	47%	45%	■	■	■	■		■
Latvia	1995	15%	$6	■	■						■	■	■	n/a	n/a	n/a	■	■				■
Slovenia	1996	24%	$20			■	■		■		■	■	■	n/a	n/a	n/a	■	■				■
Estonia	2000	3%	$3	■	■						■	■	■	n/a	n/a	n/a	■	■				■
British Columbia	2008	70%	$24	■	■	■	■	■			■	■	■	0%	0%	102%	■	■			■	
Switzerland	2008	33%	$87	■	■	■	■				■	■	■	33%	0%	67%	■	■			■	■
Iceland	2010	50%	$12	■	■	■	■	■				■	■	0%	100%	0%				■		■
Ireland	2010	40%	$24	■	■	■	■				■	■	■	13%	88%	0%	■			■		■
UK Price Floor	2013	25%	$24	■										0%	85%	0%	■		■		■	
Japan	2012	65%	$3	■	■	■	■	■	■	■	■	■	■	100%	0%	0%	■	■	■	■	■	
Australia	2012-2014	50%	$24 (2013)	■	■		■		■		■	■	■	15%	1%	53%		■	■			
France	2013	35%	$36	■	■	■	■				■	■	■	100%	0%	0%	■	■				
Mexico	2014	46%	<$1-$3	■	■	■	■	■			■		■	0%	100%	0%		■				

Sources: World Bank & Ecofys 2017, Carl & Fedor 2016, Nadal 2016, Hood 2013, Sumner et al 2011

Table 2: Cap-and-Trade Programs Implemented by 2014

Jurisdiction	Year Implemented	Emissions Coverage	2017 Price (tCO_2e)	Maximum Offsets (per entity) (I=International, D=Domestic)	Sectors Covered: Power	Industry	Buildings (Heat)	Transport	Aviation	Waste	Agriculture/Forestry	Revenue Use: Green Spending	General Fund	Revenue Recycling	Companion Policies: Energy Efficiency	Clean Energy Deployment	R&D Investment	Other Energy/Fuel Taxes	Pollutant Regulation	Carbon Tax
Norway	2005	40%	$8	11% (I)*								0%	100%	0%						
EU	2005	45%	$8	11% (I)*								80%	20%	0%						
New Zealand	2008	51%	$12	100% (D)								0%	100%	0%						
Switzerland	2008	11%	$6	4.5% (I)*								0%	100%	0%						
RGGI	2009	21%	$4	3.3% (D)								49%	32%	12%						
Tokyo	2010	20%	$13	100%(D); 30%(I)*								0%	0%	0%						
California	2012	85%	$14	8% (D)								45%	4%	55%						
Quebec	2013	85%	$14	8% (D)								100%	0%	0%						
Kazakhstan	2013	50%	$2	100% (D)								n/a	n/a	n/a						
China Cities†	2013	47%	$4	8% (D)								10%	90%	0%						

†China Cities combines data for the pilot programs in Shenzhen, Shanghai, Beijing, Tianjin, Guangdong, Hubei, and Chongqing. Reported data is an average of the values across the 7 pilot programs

*Some variation in offset limits by entity

Sources: ICAP 2018, World Bank & Ecofys 2017, Carl & Fedor 2016, Nadal 2016, Hood 2013, Sumner et al 2011

					Sectors Covered							Revenue Use			Companion Policies					
Jurisdiction	**Year Implemented**	**Emissions Coverage**	**2017 Price (tCO_2e)**	**Maximum Offsets (per entity) (I=International, D=Domestic)**	**Power**	**Industry**	**Buildings (Heat)**	**Transport**	**Aviation**	**Waste**	**Agriculture/Forestry**	**Green Spending**	**General Fund**	**Revenue Recycling**	**Energy Efficiency**	**Clean Energy Deployment**	**R&D Investment**	**Other Energy/Fuel Taxes**	**Pollutant Regulation**	**Carbon Tax**
Norway	2005	40%	$8	11% (I)*								0%	100%	0%						
EU	2005	45%	$8	11% (I)*								80%	20%	0%						
New Zealand	2008	51%	$12	100% (D)								0%	100%	0%						
Switzerland	2008	11%	$6	4.5% (I)*								0%	100%	0%						
RGGI	2009	21%	$4	3.3% (D)								49%	32%	12%						
Tokyo	2010	20%	$13	100%(D); 30%(I)*								0%	0%	0%						
California	2012	85%	$14	8% (D)								45%	4%	55%						
Quebec	2013	85%	$14	8% (D)								100%	0%	0%						
Kazakhstan	2013	50%	$2	100% (D)								n/a	n/a	n/a						
China Cities[ᵻ]	2013	47%	$4	8% (D)								10%	90%	0%						

[ᵻ]China Cities combines data for the pilot programs in Shenzhen, Shanghai, Beijing, Tianjin, Guangdong, Hubei, and Chongqing. Reported data is an average of the values across the 7 pilot programs

*Some variation in offset limits by entity

Sources: ICAP 2018, World Bank & Ecofys 2017, Carl & Fedor 2016, Nadal 2016, Hood 2013, Sumner et al 2011

References

Aldy, J. E. (2017). *The Political Economy of Carbon Pricing Policy Design* (No. ES 17-7). Harvard Project on Climate Agreements. Retrieved from https://www.belfercenter.org/sites/default/files/files/publication/aldy-ets-tax-final.pdf

Aldy, J. E., & Pizer, W. A. (2009). Issues in Designing U.S. Climate Change Policy. *The Energy Journal*, *30*(3), 179–209.

Aldy, J. E., & Pizer, W. A. (2016). Alternative Metrics for Comparing Domestic Climate Change Mitigation Efforts and the Emerging International Climate Policy Architecture. *Review of Environmental Economics and Policy*, *10*(1), 3–24. https://doi.org/10.1093/reep/rev013

Baranzini, A., Bergh, J. C. J. M. van den, Carattini, S., Howarth, R. B., Padilla, E., & Roca, J. (2017). Carbon pricing in climate policy: seven reasons, complementary instruments, and political economy considerations. *Wiley Interdisciplinary Reviews: Climate Change*, *8*(4), e462. https://doi.org/10.1002/wcc.462

Borenstein, S., Bushnell, J., Wolak, F. A., & Zaragoza-Watkins, M. (2015). *Expecting the Unexpected: Emissions Uncertainty and Environmental Market Design* (Working Paper No. 20999). National Bureau of Economic Research. https://doi.org/10.3386/w20999

Bruvoll, A., & Larsen, B. M. (2004). Greenhouse gas emissions in Norway: do carbon taxes work? *Energy Policy*, *32*(4), 493–505. https://doi.org/10.1016/S0301-4215(03)00151-4

Burtraw, D., Keyes, A., & Zetterberg, L. (2018). *Companion Policies under Capped Systems and Implications for Efficiency—The North American Experience and Lessons in the EU Context*. Resources for the Future. Retrieved from http://www.rff.org/files/document/file/RFF-Rpt-Companion%20Policies%20and%20Carbon%20Pricing_0.pdf

Carl, J., & Fedor, D. (2016). Tracking global carbon revenues: A survey of carbon taxes versus cap-and-trade in the real world. *Energy Policy*, *96*, 50–77. https://doi.org/10.1016/j.enpol.2016.05.023

Colman, Z., & Sobcyzk, N. (2018, July 17). House Republican will introduce $23 carbon tax next week. *E&E News*. Retrieved from https://www.eenews.net/stories/1060089315

Denniss, R., Grudnoff, M., & Macintosh, A. (2012). Complementary Climate Change Policies: A Framework for Evaluation. *The Economic and Labor Relations Review*, *23*(1), 33–46.

Diamant, A. (2013). *Exploring the Interaction Between California's Greenhouse Gas Emissions Cap-and-Trade Program and Complementary Emissions Reduction Policies* (Technical Report No. 3002000298). Palo Alto, CA: Electric Power Research Institute.

Egan, P. J., & Mullin, M. (2017). Climate Change: U.S. Public Opinion. *Annual Review of Political Science*, *20*, 209–227.

Ellerman, A. D., Convery, F. J., & de Perthuis, C. (2010). *Pricing Carbon: The European Union Emissions Trading Scheme*. Cambridge University Press.

Fell, H., Burtraw, D., Morgenstern, R. D., & Palmer, K. L. (2012). Soft and hard price collars in a cap-and-trade system: A comparative analysis. *Journal of Environmental Economics and Management*, *64*(2), 183–198. https://doi.org/10.1016/j.jeem.2011.11.004

Goulder, L. H., Hafstead, M. A. C., & Dworsky, M. (2010). Impacts of alternative emissions allowance allocation methods under a federal cap-and-trade program. *Journal of Environmental Economics and Management, 60*(3), 161–181. https://doi.org/10.1016/j.jeem.2010.06.002

Goulder, L. H., & Parry, I. W. H. (2008). Instrument Choice in Environmental Policy. *Review of Environmental Economics and Policy*, *2*(2), 152–174. https://doi.org/10.1093/reep/ren005

Goulder, L. H., & Schein, A. R. (2013). Carbon taxes versus cap and trade: a critical review. *Climate Change Economics, 04*(03), 1350010. https://doi.org/10.1142/S2010007813500103

Goulder, L. H., & Stavins, R. N. (2012). Interactions between State and Federal Climate Change Policies. In *The Design and Implementation of U.S. Climate Policy* (pp. 109–121). University of Chicago Press. Retrieved from http://www.nber.org/chapters/c12124.pdf

Green, J. F. (2017). Don't link carbon markets. *Nature News*, *543*(7646), 484. https://doi.org/10.1038/543484a

Haites, E., Maosheng, D., Gallagher, K. S., Mascher, S., Narassimhan, E., Richards, K. R., & Wakabayashi, M. (2018). *Experience with Carbon Taxes and Greenhouse Gas Emissions Trading Systems* (SSRN Scholarly Paper No. ID 3119241). Rochester, NY: Social Science Research Network. Retrieved from https://papers.ssrn.com/abstract=3119241

Hood, C. (2013). *Managing interactions between carbon pricing and existing energy policies* (Insight Series). International Energy Agency.

ICAP. (2018). *Emissions Trading Worldwide: Status Report 2018*. Berlin: ICAP.

IETA. (2015). *Overlapping Policies with the EU ETS*. International Emissions Trading Association. Retrieved from http://www.ieta.org/resources/EU/Overlapping_Policies_Drafting_Group/ieta_overlapping_policies_paper_10072015_final.pdf

IRENA. (2016). *The Power to Change: Solar and Wind Cost Reduction Potential to 2025*. IRENA. Retrieved from /publications/2016/Jun/The-Power-to-Change-Solar-and-Wind-Cost-Reduction-Potential-to-2025

Jenkins, J. (2014, July 29). When Politics Constraints Carbon Pricing, Part 3: Why Carbon Revenues are Just as Important as "Putting a Price on Carbon." Retrieved March 29, 2018, from http://theenergycollective.com/jessejenkins/444186/when-politics-constraints-carbon-pricing-part-3-why-carbon-revenues-are-just-imp

Leining, C., & Kerr, S. (2016). *Lessons Learned from the New Zealand Emissions Trading Scheme* (Working Paper No. 16–06) (p. 47). Motu Economic and Public Policy Research.

Metcalf, G. E., & Weisbach, D. (2009). The Design of a Carbon Tax. *Harvard Environmental Law Review*, *33*, 499–556.

Murray, B. C., & Maniloff, P. T. (2015). Why have greenhouse emissions in RGGI states declined? An econometric attribution to economic, energy market, and policy factors. *Energy Economics*, *51*, 581–589. https://doi.org/10.1016/j.eneco.2015.07.013

Murray, B. C., Newell, R. G., & Pizer, W. A. (2009). Balancing Cost and Emissions Certainty: An Allowance Reserve for Cap-and-Trade. *Review of Environmental Economics and Policy*, *3*(1), 84–103. https://doi.org/10.1093/reep/ren016

Murray, B. C., Pizer, W. A., & Reichert, C. (2017). Increasing Emissions Certainty under a Carbon Tax. *Harvard Environmental Law Review Forum*, *41*, 14–27.

Nadal, S. (2016). *Learning from 19 Carbon Taxes: What Does the Evidence Show?* American Council for an Energy-Efficient Economy. Retrieved from https://aceee.org/files/proceedings/2016/data/papers/9_49.pdf

Parry, I., Veung, C., & Heine, D. (2015). How much carbon pricing is in countries' own interests? the critical role of co-benefits. *Climate Change Economics*, *06*(04), 1550019. https://doi.org/10.1142/S2010007815500190

Pigou, A. C. (1932). *The economics of welfare, 1920*. London: McMillian & Co.

Rohling, M., & Ohndorf, M. (2012). Prices vs. Quantities with fiscal cushioning. *Resource and Energy Economics*, *34*(2), 169–187. https://doi.org/10.1016/j.reseneeco.2011.10.004

South Africa Minister of Finance. Draft Carbon Tax Bill December 2017.pdf, § 77 (2017). Retrieved from http://www.treasury.gov.za/public%20comments/CarbonTaxBll2017/Draft%20Carbon%20Tax%20Bill%20December%202017.pdf

Stavins, R. N. (2008). A Meaningful U.S. Cap-and-Trade System to Address Climate Change. *Harvard Environmental Law Review*, *32*, 293–372.

Sumner, J., Bird, L., & Dobos, H. (2011). Carbon taxes: a review of experience and policy design considerations. *Climate Policy*, *11*(2), 922–943. https://doi.org/10.3763/cpol.2010.0093

Temple, J. (2017, December 4). A surge of state carbon pricing proposals are coming, and shifting electoral math mean many may pass. Retrieved March 24, 2018, from https://www.technologyreview.com/s/609560/surge-of-carbon-pricing-proposals-coming-in-the-new-year/

US EPA. Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units, Pub. L. No. 205, 80 Federal Register 64661 (2015). Retrieved from https://www.gpo.gov/fdsys/pkg/FR-2015-10-23/pdf/2015-22842.pdf

US EPA. Repeal of Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units, Pub. L. No. 198, 82 Federal Register 48035 (2017). Retrieved from https://www.gpo.gov/fdsys/pkg/FR-2017-10-16/pdf/2017-22349.pdf

Wara, M. W., & Victor, D. G. (2008). *A Realistic Policy on International Carbon Offsets* (Working Paper No. #74). Program on Energy and Sustainable Development at Stanford University. Retrieved from https://web.stanford.edu/dept/france-stanford/Conferences/Climate/Wara.pdf

Webber, D. J. (1986). Analyzing Political Feasibility: Political Scientists1 Unique Contribution to Policy Analysis. *Policy Studies Journal*, *14*(4), 545–553. https://doi.org/10.1111/j.1541-0072.1986.tb00360.x

Weitzman, M. L. (1974). Prices vs. Quantities. *The Review of Economic Studies*, *41*(4), 477–491. https://doi.org/10.2307/2296698

Weyant, J. P. (1993). Costs of Reducing Global Carbon Emissions. *Journal of Economic Perspectives*, *7*(4), 27–46. https://doi.org/10.1257/jep.7.4.27

World Bank Group, & Ecofys. (2017). *Carbon Pricing Watch: 2017*.

York, R. (2008). De-Carbonization in Former Soviet Republics, 1992–2000: The Ecological Consequences of De-Modernization. *Social Problems*, *55*(3), 370–390. https://doi.org/10.1525/sp.2008.55.3.370