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Cutting with both arms of the scissors: the economic and political case for restrictive supply-side climate policies

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Abstract Proponents of climate change mitigation face difficult choices about which types of policy instrument(s) to pursue. The literature on the comparative evaluation of climate policy instruments has focused overwhelmingly on economic analyses of instruments aimed at restricting demand for greenhouse gas emissions (especially carbon taxes and cap-and-trade schemes) and, to some extent, on instruments that support the supply of or demand for substitutes for emissions-intensive goods, such as renewable energy. Evaluation of instruments aimed at restricting the upstream supply of commodities or products whose downstream consumption causes greenhouse gas emissions—such as fossil fuels—has largely been neglected in this literature. Moreover, analyses that compare policy instruments using both economic and political (e.g. political "feasibility" and "feedback") criteria are rare. This article aims to help bridge both of these gaps. Specifically, the article demonstrates that restrictive supply-side policy instruments (targeting fossil fuels) have numerous characteristic economic and political advantages over otherwise similar restrictive demand-side instruments (targeting greenhouse gases). Economic advantages include low administrative and transaction costs, higher abatement certainty (due to the relative ease of monitoring, reporting and verification), comprehensive within-sector coverage, some advantageous price/efficiency effects, the mitigation of infrastructure "lock-in" risks, and mitigation of the "green paradox". Political advantages include the superior potential to mobilise public support for supply-side policies, the conduciveness of supply-side policies to international policy cooperation, and the potential to bring different segments of the fossil fuel industry into a coalition supportive of such policies. In light of these attributes, restrictive supply-side policies squarely belong in the climate policy "toolkit".

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> We might as reasonably dispute whether it is the upper or the under blade of a pair of scissors that cuts a piece of paper, as whether value is governed by utility [demand] or cost of production [supply].
>
> Alfred Marshall, *Principles of Economics* (1890, bk. III, 28)

1 Introduction

Proponents of climate change mitigation face difficult choices about which policy instrument(s) to pursue. The climate policy "toolkit" is large, and many competing criteria, both normative and political, are relevant to the choice (Goulder and Parry 2008, 152). Economists and policymakers have focused overwhelmingly on comparisons among policy instruments that aim to *restrict demand* for greenhouse gases, particularly cap-and-trade schemes and carbon taxes, as these are seen to perform better than alternatives against economists' favoured criteria of "economic efficiency" and its close relative, "cost-effectiveness", when tested using simple economic models (ibid). There has also been considerable scholarly attention paid to policies that *support the supply of or demand for substitutes* of energy-intensive or emissions-intensive goods, such as renewable energy (Somanathan et al. 2014, sec. 15.6) (see unshaded quadrants of Table 1, below).

But the comparative literature on climate policy instrument choice has been remarkably silent on instruments that aim to *restrict the supply* of commodities and products whose downstream consumption produces greenhouse gas emissions ("restrictive supply-side climate policies"), of which measures to restrict fossil fuel energy supply are the most relevant (see shaded quadrant of Table 1). For example, in Goulder and Parry's "toolkit of environmental instruments" not one restrictive supply-side policy is mentioned (Goulder and Parry 2008, 152). Nor is any mentioned in the chapter on "National and Sub-national Policies and Institutions" of the IPCC's Working Group III (Somanathan et al. 2014).[1] The seminal work of Sinn on the economics of supply-side climate policy (Sinn 2008; Sinn 2012), and more recent economic analysis of particular supply-side climate policy proposals (for useful summaries, see Lazarus et al. 2015 and Collins and Mendelevitch 2015), have not been systematically incorporated into the climate policy "toolkit". Nor have such policies been widely championed by policymakers: as Lazarus et al. surmise, "despite the increased attention, supply-side climate policies have yet to take hold in most of the world" (Lazarus et al. 2015, 3).

This relative neglect by the mainstream climate policy community is prima facie surprising since, as we show in Section 2, restrictive supply-side policies are sound in economic theory and widely used in a range of other policy domains. The primary contribution of this article, however, lies in Sections 3 and 4, which demonstrate, respectively, the main *economic* (efficiency and effectiveness) and *political* (feasibility and "feedback") advantages of restrictive supply-side climate policies.

While the economic analysis of climate policy instruments has a long pedigree, many readers may be less familiar with political science concepts and frameworks for analysing

[1] Intertemporal leakage is mentioned on page 1163, but only as a factor to be taken into consideration in the design of carbon pricing.

Table 1 The climate policy toolkit

	Supply-side	Demand-side
Restrictive	*Restrictive supply-side climate policies* (e.g. FF subsidy reduction; FF supply tax; FF production quotas; FF supply ban/moratorium)	*Restrictive demand-side climate policies* (e.g. carbon tax; carbon cap-and trade; mandatory CO_2 emissions standards)
Supportive (of substitutes)	*Supportive supply-side climate policies* (e.g. direct government provision of low-carbon infrastructure; R&D subsidies; renewable energy feed-in-tariffs)	*Supportive demand-side climate policies* (e.g. government procurement policies; consumer subsidies for energy-efficient or low-emitting substitutes)

Notes: FF = fossil fuels. Shaded area represents the focus of this article; unshaded areas are those typically analysed in the comparative literature on climate policy instruments.

climate policy instruments. Political analysis of generic policy instruments and design features matters for two reasons. First, not all policy instruments and design features may be immediately politically feasible to enact in a given context (and those that *are* feasible may be far from "optimal": Jenkins 2014). Systematic attention to the characteristic political effects of alternative policy instruments can inform judgements about their relative feasibility in a particular context. Second, it is not only the case that the feasibility of a given climate policy instrument and design choice is *affected by* (past/present) politics: climate policies themselves, by (re-)allocating resources, creating institutions, incentivising investments and influencing culture, also *affect* patterns of politics and power relations in subtle but crucial ways, in turn shaping what becomes feasible in the future (Cook 2010); climate policy choices, in other words, create "feedback effects" (Jordan and Matt 2014). Yet, in the comparative literature on climate policy instrument choice, if political feasibility is considered at all it is often treated in a "static" way that ignores the potential for relevant instruments to generate such feedback effects (Urpelainen 2013, 110, 120). A secondary contribution of this article (specifically Section 4) is the application of a framework developed by the authors for the comparative evaluation of the political dimensions of climate policy instruments. This framework, which draws on the extensive literature on the politics of climate policy, can, we suggest, usefully be employed more generally in comparative climate policy instrument evaluation.

Throughout the discussion, we focus on policies aimed at restricting the supply of *fossil fuels*—undoubtedly the most important class of restrictive supply-side policies. A useful typology of such policies is provided by Lazarus et al. (2015, 10, Table 1), but our intention is to control for differences between generic instrument types (e.g. "command and control regulation", "market mechanism" etc.), focusing instead on the marginal benefits of (restrictive) instruments that target the *supply side* relative to those that target the *demand side*. The comparison is *not* intended to show that supply-side instruments are *all things considered* superior to demand-side instruments. The economic attributes of the latter have, as noted earlier, already been extensively established. Rather, our more modest aim is to establish the distinctive economic and political benefits of supply-side instruments with a view to these taking their rightful place in the climate policy toolkit *alongside* the other kinds of policies listed in Table 1. Our hope is that, with these benefits in mind, the potential for supply-side instruments to act as economic and political complements or substitutes for demand-side instruments in a given context can be evaluated on a case-by-case basis.

The scope of our analysis is limited in three significant ways. First, in the interests of simplicity, we consider the economic and political cases separately from one another, and in isolation from other climate and non-climate policy instruments. Second, we consider only generic, typical benefits of supply-side policies; the magnitude of the effects we analyse is likely to vary cross-contextually (e.g. cross-nationally). Third, we mostly consider the three fossil fuel types (coal, oil and gas) together, abstracting from differences between them. We consider in Section 5 various research directions that could build upon our analysis to address these limitations.

2 The value and ubiquity of supply-side policies in other domains

A negative externality is said to exist when the production or consumption of a product imposes costs on a party that is not involved in the sale or purchase of that product. Under such circumstances, the market price will be lower, and the quantity supplied higher, than the social optimal levels. To address negative externalities, economists typically recommend a range of policy options drawn from all quadrants of Table 1, and covering instruments ranging from so-called "command and control" regulation to "market mechanisms" to information/behaviour change campaigns. Significantly, many countries rely on complicated and evolving combinations of these measures, wherein restrictive supply-side policies play an important role complementing demand-side policies.

Policies to control tobacco smoking in Australia provide an instructive example. The policy mix includes prohibitions on producing tobacco without a license, selling tobacco without a license, selling tobacco to children, tobacco advertising, tobacco sponsorship, and smoking cigarettes in confined public spaces. It also includes heavy taxation of tobacco consumption, hard-hitting public information campaigns, "plain packaging" laws, mandatory health warnings on cigarette packages, and the subsidisation of certain substitutes for cigarettes such as nicotine patches. Far from being derided as an inefficient mire of "red tape", Australia's tobacco regulatory environment is lauded as a global model of effective public health policy, with the country seen as an early mover in innovative regulation in the sector (Chapman and Wakefield 2001). The combination of a wide range of policies, rather than *an 'optimal' policy*, is, moreover, endorsed in the *World Health Organisation Framework Convention on Tobacco Control*, which states that "'tobacco control' means a range of supply, demand and harm reduction strategies that aim to improve the health of a population by eliminating or reducing their consumption of tobacco products and their exposure to tobacco smoke…" (article 1(d)).

Restrictive supply-side policies have also played an important role in efforts to reduce negative environmental pollution externalities, including chlorofluorocarbons (Haas 1992), asbestos (Kameda et al. 2014), and lead in petroleum products (Needleman 2000).

Given the widespread use of restrictive supply-side policies in other policy domains, their relative neglect in the climate policy domain seems anomalous. In the following sections, we argue that restrictive supply-side climate policies targeting fossil fuels (hereafter simply referred to as "supply-side policies") indeed have distinctive economic and political benefits, in view of which this neglect is unwarranted.

3 The economic benefits of supply-side policies

3.1 Low administrative and transaction costs, higher certainty of abatement outcomes, and comprehensive within-sector coverage

Policy instruments vary in the administrative and transaction costs they entail. The administrative and transaction costs of demand-side climate instruments are often considerable. Both carbon taxes and cap-and-trade schemes require detailed and complex rules, procedures and regulatory institutions for the monitoring, reporting and verification (MRV) of greenhouse gas emissions at facility/installation level (e.g. power plants, steel mills), often across hundreds or even thousands of facilities/installations (Helm 2005, 212).

The complexity of facility-level greenhouse gas MRV reduces the efficiency of such instruments in three ways. First, the imposition of non-trivial transaction and administrative costs itself reduces efficiency. Second, information about greenhouse gas emissions at facility/installation level is strongly asymmetrical in favour of regulated entities, making it difficult for policymakers to avoid the deliberate "gaming" and the inadvertent underreporting of emissions, both of which can reduce the actual (as opposed to *reported*) environmental outcomes of carbon pricing schemes (Bellassen et al. 2015; Kuch 2015). Third, due to administrative and transaction costs, liability in actual demand-side schemes is inevitably limited to large emitters—those whose emissions exceed a legally-specified threshold—necessarily rendering scheme coverage incomplete, which further reduces efficiency (Bellassen et al. 2015).[2]

Supply-side policies, by contrast, are likely to have relatively low administrative and transaction costs. First, they target a relatively small number of large, easily identifiable projects operated by administratively competent firms upstream in the fossil fuel supply chain. Second, the commodities to be accounted for (especially coal and oil) are not only much easier to monitor/measure than greenhouse gases, but they are typically already measured by firms for existing administrative purposes such as resource tax liability assessment and compliance with local environmental license conditions. For these reasons, total (and average-per-firm) MRV costs, MRV-related uncertainties in abatement outcomes, and the degree of information asymmetry are all likely to be lower than for similar demand-side instruments (Kerr and Duscha 2014, 596–99). Third, supply-side policies automatically achieve very high levels of coverage because all downstream consumers (subject to any constraints in cost pass-through) face higher prices for fossil fuel inputs and are thus encouraged to reduce those inputs (ibid, 597).

3.2 Price and efficiency effects

Restricting the supply of a product, all else equal, increases the market price of that product. Restricting fossil fuel supply will thus raise the absolute and relative price of products that use fossil fuels as inputs. To the extent that higher prices discourage consumption (the premise on which restrictive demand-side policies such as carbon pricing is based), the higher fossil fuel prices will cause a reduction in the quantity consumed.

[2] The further significance of these points for the choice of optimal policy instrument is discussed in Section 3.2.

In theory, the creation of technology- and pollutant-neutral policy instruments, such as a cap-and-trade scheme with universal coverage of greenhouse gases, sectors and facilities, allows for "least cost abatement" as profit-maximising agents search for the optimal combination of supply- and demand-side responses across all abatement channels (e.g. investment in renewable energy, sequestration in forests, or reduced passenger car use) (Goulder and Parry 2008, 154–59). However, in order to reduce the administrative and MRV costs (discussed above) and overcome political constraints (discussed in Section 4) real-world carbon price schemes inevitably are not universal in their coverage of sectors and facilities. This reduces the theoretical efficiency benefits of market-based demand-side schemes because it precludes the use of particular abatement channels (Denniss 2008). Consequently, the efficiency difference between a real-world carbon price and a restriction in the supply of fossil fuels will be smaller in practice than in theory.

In a world where optimal climate policy is not achievable, it would be beneficial to augment demand-side policies with supply-side policies. The main reason for this is that when demand-side policies succeed in reducing emissions in one country the decrease in demand for fossil fuels can result in lower prices being paid for fossil fuels in other countries (where the relevant market is international). While in a first-best world of global carbon pricing such an effect would not be possible, no such global policy is likely to arise anytime soon, and at present the climate and energy policies of large energy users such as the USA, China and India have significant ability to influence the world prices for each type of fossil fuel. Price reductions that accompany a decrease in demand can slow the global pace of industrial transformation toward low-carbon production. For goods that do not generate negative externalities, the slowing of industrial transformation caused by such price falls is advantageous as it helps maximise the utilisation of existing capital and labour. But when the objective of demand-side policy is to *accelerate* industrial transformation, restrictive supply-side policy has an important role to play in limiting countervailing price effects. The *combination* of supply-side and demand-side policies will thus hasten the industrial transformation required to meet climate mitigation objectives.

3.3 Avoiding infrastructure lock-in

When production processes require a large, upfront investment in fixed costs, such as the construction of a port, pipeline or coalmine, future production will take place even when the market price of the resultant product is lower than the long-run opportunity cost of production. This is because rational producers will ignore "sunk costs" and continue to produce as long as the market price is sufficient to cover the marginal cost (but not the average cost) of production. This is known as "lock-in" (see generally Seto et al. 2016, 429–30; see Erickson et al. 2015 on lock-in from fossil fuel supply infrastructure specifically). (Even if the price of the product is sufficiently low as to prevent the asset owner from repaying debts associated with the fixed costs, the bankruptcy of the owner will not prevent subsequent owners of the fixed asset from producing, so long as the market price covers the marginal cost of production.)

When future policy is uncertain, a rational investor might be willing to make a large upfront investment in fixed production capacity (for example building a new coalmine) if they assess the short-term value of the profits that can be earned under current policy settings to be greater than the long-term (risk-adjusted) cost of detrimental policy

change. However, if a rational investor significantly underestimates the probability of policy change (such as the timing and extent of a future carbon price), then, even after the original rational (but mistaken) investor loses their financial capital, the market price of the relevant fossil fuel would still be lower than would have otherwise been the case had the investor accurately assessed the probability of policy change. The temporary inability of an investor to assess future policy risk can thus have a durable impact on the market.

Under such circumstances, policymakers can use restrictive supply-side policies both to send a clear signal to investors about the path of future policy and, in turn, to avoid inefficiently high levels of investment in the production capacity for goods of which policymakers are determined to reduce consumption in the future.

3.4 Mitigating the 'green paradox'

The risk of future policy change to the current value of a resource—for example, the risk of a future carbon price reducing the current value of coal resources—can induce resource owners to bring forward their extraction of that resource, thereby reducing its market price, causing an increase in its consumption (a phenomenon dubbed "the Green Paradox" by Sinn 2008, 2012).[3] Supply-side policies can be a straightforward means to mitigate the impact of the Green Paradox (Sinn 2008, 2012).[4]

4 The political benefits of supply-side policies

4.1 Greater potential to mobilise public support for policy

Choice of policy instrument and associated design features can affect public support for climate policies (see Drews and van den Bergh 2015). Empirical and experimental evidence shows that, holding constant non-policy-related factors, public support for restrictive climate policies depends on (i) the perceived benefits of the policy, (ii) the perceived personal and public costs of the policy, and (iii) the perceived distributional fairness of the policy (ibid, 860–63). Perceptions of benefits and costs are also influenced by people's perceptions of the effectiveness of the policy, which are in turn affected by their understanding of the causal mechanisms by which the policy is supposed to achieve its objectives (ibid).

Scholars have identified various reasons, related to these factors, why people tend to prefer certain kinds of climate policy *instruments* over others (e.g. command and control regulation over market-based instruments) (Jenkins 2014; Karplus 2011; Rabe 2010) and, within a given class of policy instrument, certain *design features* (e.g. explicit earmarking of revenue from market-based instruments) (Drews and van den Bergh 2015, 863; Rabe and Borick 2012). What has not been analysed is the effect on public support resulting from *whether the instrument targets the supply side or the demand side*

[3] The circumstances in which this phenomenon might cause increased emissions are discussed in van der Ploeg and Withagen (2012) and Edenhofer and Kalkuhl (2011).

[4] While Pigouvian taxes are the preferred theoretical solution to this problem and various other market failures, when the difficulties of designing and implementing optimal tax policies are taken into account, supply-side policies are likely to be a preferable "second-best" option.

(controlling for instrument type and relevant design features such as, where applicable, revenue allocation).

We argue that, on each of the abovementioned three factors, supply-side policies are generally likely to attract higher public support than demand-side policies, all else equal.

4.1.1 Higher perceived benefits of supply-side policy

The first reason supply-side policies are likely to receive stronger public support is because they foreground (render salient) benefits that people value more.

Demand-side instruments (e.g. carbon pricing; carbon efficiency standards) typically focus on greenhouse gas abatement per se. But this is a weakly valued benefit. A common conclusion from climate-related public opinion research is that climate science is poorly understood and concern about the problem, though widespread, is shallow, i.e. it tends to be a low-salience, low-priority concern and individuals have a low "willingness to pay" for solutions (Ansolabehere and Konisky 2014; Guber 2003; Jenkins 2014, 470–72; van der Linden et al. 2015). This is unsurprising: the climate benefits of mitigation policies are diffused widely across time and space; they disproportionately accrue (and are perceived accrue) to future generations and people in other countries; and their magnitude is uncertain, meaning they are likely to be strongly discounted by voters (van der Linden et al. 2015). The weak valuation of climate benefits may also be linked to the perceived ineffectiveness of unilateral domestic climate policies in tackling global climate change (Drews and van den Bergh 2015, 860–61). In any case, insofar as they foreground climate benefits, demand-side instruments face major challenges in attracting strong public support (Jenkins 2014, 475; Rabe and Borick 2012). This challenge is often magnified in public debates about such policies: in their public-facing campaigns to discredit such policies, opposing interest groups can easily exploit the public's weak valuation of climate benefits and doubts about the policy's effectiveness, as exemplified by case studies of carbon pricing debates in Australia (Chubb 2014), Canada (Harrison 2012) and the US (Skocpol 2013).

By contrast, supply-side instruments typically target fossil fuels per se. Survey evidence suggests that people more readily link co-costs/co-benefits (environmental, health, security, social, economic) to specific energy sources than to the more abstract concepts of "carbon"/"climate" (e.g., Ansolabehere and Konisky 2014); and fossil fuels are well-understood commodities that many people more readily associate with a range of higher-priority, more localised and more immediate negative (non-climate) impacts, resulting in negative attitudes toward fossil fuels, especially coal (see Green 2018, section 3.1.1 and references there cited). These features give supply-side policies considerable advantages in attracting public support for climate policy. Relatively high public support for fossil fuel severance (resource extraction) taxes, even in climate-ambivalent, tax-averse north-American states and provinces (Rabe and Borick 2012, 377–79), provides circumstantial empirical support for these arguments.

The foregrounding of a wider and more valued set of benefits is also likely to make it easier for proponents of supply-side policies to "mobilise" the public to participate actively in (consciously or incidentally) pro-climate-policy political action (Bomberg 2012) because this: enables proposals to be framed in ways that are more resonant with voters and more resilient to counter-attack by opposing interest groups; facilitates alliance-building among diverse groups with wide-ranging concerns about fossil fuels;

and facilitates network-building among groups at different advocacy- and policy-relevant scales (Green 2018). These are, additionally, positive feedback effects that increase the likelihood of stronger climate policies in the future (ibid).

4.1.2 Possible higher perceived distributional fairness and lower perceived costs of supply-side policies

The higher they perceive the costs of a climate policy to be (to themselves and to society more broadly), the less likely people are to support it, all else equal (Drews and van den Bergh 2015, 861–62). But the perceived fairness of the distribution of those costs across society also affects voter support for climate policies (ibid, 862). Survey evidence (Cai et al. 2010) and case studies from carbon pricing attempts in Australia (Chubb 2014) and Canada (Harrison 2012) suggest that people are more likely to support a climate policy where they perceive that the incidence of the policy's costs will likely lie with polluting industries.

From the case studies just cited, it appears, further, that people tend to perceive that energy consumers will bear the incidence of costs imposed under carbon pricing instruments, which contributes to the weak public support for such policies. Undoubtedly, part of the perception is attributable to the policy instruments analysed in those case studies being "price" instruments, which foreground the price that consumers must pay on salient household consumption items like electricity and gasoline, making them less popular than "command and control" instruments that "hide the costs" of regulation (Jenkins 2014; Karplus 2011; Keohane et al. 1998; Rabe 2010; Rabe and Borick 2012). However, we hypothesise that part of the opposition to carbon prices is explained by the fact that the instruments are *demand-side* instruments. In a relevant supply chain, the formal incidence of demand-side instruments generally lies with, or close to, the end consumers. So too in the case of demand-side climate policies applicable to the energy sector: the formal incidence, or liability, typically lies with owners (or operators) of electricity generation facilities and petroleum distributors. The fact that consumers regularly buy electricity and gasoline, we suggest, makes consumers more readily perceive that the costs will be passed onto them. If this hypothesis is correct, it follows that people are more likely to perceive the incidence of supply-side policies to lie with fossil fuel producers, since the latter are more remote from consumers in relevant supply chains. Accordingly, we would expect that people would perceive the costs to themselves of supply-side policies to be lower, or the distribution of the costs to be fairer, or both—and thus support for such policies to be higher. The stronger preferences for fossil fuel severance taxes than for demand-side energy taxes in North America is again consistent with this hypothesis, though research designed to test this hypothesis is needed, and would be a valuable subject of future research.

Additionally, insofar as (the public perceives that) the fossil fuels mined or extracted in the relevant jurisdiction (e.g. country *A*) will be exported to another jurisdiction (e.g. country *B*), the effects of price increases on consumer surplus—which may well be large—will be felt in country *B*, not country *A*. Accordingly, voters in country *A* are likely to perceive that the personal costs of supply-side policies will be low (subject to concerns about production leakage), implying stronger public support for supply-side policy in country *A* (see also Rabe and Borick 2012, 377–79).

4.2 Different potential to mobilise fossil fuel industry support for policy

A major political barrier to the enactment of (ambitious) restrictive climate policies (Table 1, row 1) in the energy sector is the political mobilisation of industries that stand to lose from such policies. Fossil fuel producers are especially politically influential: they are characteristically well organised, capital-intensive, and own highly specific assets (Hughes and Lipscy 2013, 459); and they often have deep ties to the states in which they operate (Newell and Paterson 1998). Environmental nongovernmental organisations and green industries typically form coalitions supportive of climate policy, but these are typically weak compared with the power of the opposing coalition (Meckling et al. 2015). The political feasibility of climate policy improves when, all else equal, members of the opposing coalition are induced to switch from opposition to support.

Policy can be crafted so as to divide otherwise-opposed fossil fuel companies and recruit some of them to the supporting coalition. Here, two standard policy design features are most relevant. First, fossil fuel companies can be divided along "temporal" (incumbent vs new entrant) lines by using instruments that restrict new entrants. Bans/moratoria are particularly well-suited to this task, since precluding new entrants is the *raison d'etre* of such a policy. Second, fossil fuel companies can be divided along "sub-industry" (e.g. coal vs. petroleum) lines by applying the policy only to one or some sub-industries. Rational fossil fuel producers perceiving a risk of a tightening carbon budget constraint will support policies that require emissions reductions from other sectors, including other fossil fuel sub-industries, but which exclude their own sector.

While both restrictive demand-side and restrictive supply-side policies can be designed to have one or both of these features, the relative political feasibility of such demand-side vs supply-side schemes is likely to vary from case to case. In a given context (e.g. country *A* at time *t*), the industry structure (e.g. market concentration), industry size, and demand outlook for the products of (particular kinds of) fossil fuel suppliers relative to (particular kinds of) industrial fossil fuel consumers may be more conducive to policies targeting suppliers of a fossil fuel than consumers of that fuel (and these are all likely to vary systematically across fuel types). In other contexts, of course, the opposite may hold. For example, where some of a country's fossil fuel production is exported, fossil fuel producers in that country are likely to prefer demand-side over supply-side policies, other things equal (cf. Harrison 2015, 39).[5]

Given the high political value of strengthening the supportive coalition relative to the opposing coalition, considerations concerning the potential to win over fossil fuel (sub-)industries to supporting coalitions should be of great interest to policymakers. In light of the different coalitional implications they are likely to have in a given context, inclusion of supply-side policies in the policy toolkit (alongside demand-side policies) will expand the option set of policymakers confronted by powerful industries.

4.3 Greater potential to induce, sustain and escalate international policy cooperation over time

So far, we have focused on the effect of instrument choice at the domestic level. But of course, domestic climate policies both influence and are influenced by actors, institutions

[5] This is the converse implication of the point made at the end of Section 4.1.2: supply-side policies affecting the exports of Country *A* reduce consumer surplus in the importing Country *B*, but they reduce producer surplus in Country *A* (relative to an equivalent demand-side measure in Country *A* that does not affect emissions embodied in exports).

and ideas at the international level, and those emerging from within other countries. One relevant criterion of instrument choice, then, is the conduciveness of a policy instrument to international cooperation or transnational policy diffusion (cf. Hepburn 2006, 235), which can be specified as the extent to which a policy instrument can be expected to induce, sustain or escalate international policy cooperation or transnational policy diffusion.

Serious attempts at strong forms of policy linkage and harmonisation using demand-side carbon pricing instruments have been all-but-abandoned in the design of the Paris Agreement. Moreover, the significance of uniform territorial emissions accounting has been much diminished in the move away from a regulatory regime focused on technical compliance (as with the Kyoto Protocol) to a facilitative regime focused on mobilising political pressure to raise countries' ambition, along multiple dimensions, over time (as with the Paris Agreement) (see the Electronic Supplementary Material in Green 2018). These political realities of the new regime have opened the space for new forms of instrument-specific international cooperation. There are two features of supply-side policies that make them potentially more conducive to international cooperation and/or policy diffusion.

First, if price elasticities of demand for a fossil fuel are high relative to supply elasticities for that fuel, supply-side policies will result in less international carbon leakage than demand-side policies (Lazarus et al. 2015, 14–15). Collier and Venables argue that, at least for coal, long-run elasticities of demand are likely to exceed those of supply because the many substitution possibilities available on the demand-side (other fossil fuels, renewables) "have no analogue on the supply side; producing less coal has no technological link to having a greater supply of oil, gas, or renewables" (Collier and Venables 2015, 497–98). Ultimately, determining the relative supply vs demand elasticities for each fuel type is an empirical matter that lies beyond the scope of this paper, and for some fuels the relative elasticities may vary from market to market.[6] But to the extent that supply elasticities *are* lower than demand elasticities, unilateral domestic supply-side policies would be more effective at reducing global emissions than their demand-side equivalents. That effect would be desirable on its own, but it would also help to build international cooperation: the emergence of international cooperation on fossil fuels is likely to be contingent on a coalition of early-movers taking unilateral steps to limit or reduce fossil fuel supply (i.e. "leading by example" and then persuading or incentivising other states to adopt similar restrictions: Green 2018); low international leakage rates associated with supply-side policies would encourage the necessary unilateral action.

The second feature is the relative ease with which supply-side policies can be monitored and verified (see Section 3.1). Were states to commit internationally to implement supply-side policies, the ease of MRV would mean third states (and other third-party agents, such as nongovernmental organisations) could readily verify compliance with those international commitments (Collier and Venables 2015, 501, 506–7; Kerr and Duscha 2014, 599). This matters greatly for international cooperation because when states know that compliance can easily be verified by third parties, they are more likely to comply (Chayes and Chayes 1991, 320–21). Moreover, mutually verified compliance builds trust among states, which encourages states to escalate their commitments over time as repeated cycles of reciprocal action-and-verification build their confidence in the integrity of a cooperative regime (Bell et al. 2012; Victor 2011). This kind of gradual escalation strategy has proved successful in other international policy domains where reliable and timely verification was feasible and emphasised (Bell

[6] Lazarus et al. (2015, 15), reviewing the empirical literature, find that elasticities of supply used in studies of coal markets vary depending on the region, while elasticities of similar magnitudes for demand and supply have been used in analyses of oil markets.

et al. 2012; Victor 2011). Since the Paris Agreement's success is predicated on states' gradual escalation of their commitments over time, commitments to implement supply-side policies offer major advantages as a "currency" of international climate cooperation (e.g. as key measures in countries' Nationally Determined Contributions[7]). By contrast, attempts to build international cooperation using demand-side instruments are beset by seemingly interminable, trust-sapping arguments about accounting rules and verification mechanisms for greenhouse gas emissions (see, e.g., Kuch 2015).

5 Conclusion

To our knowledge, this article is the first attempt to integrate and synthesise the economic and political attributes of restrictive supply-side climate policies. The article has argued that such policies (i) can overcome a number of climate-related economic inefficiencies that are unaddressed, or caused, by demand-side policies; and (ii) have a number of political advantages over demand-side policies. In view of their potential economic and political benefits, we conclude that the neglect of restrictive supply-side climate policies in policy discussions and in the comparative academic literature on policy instrument choice is unwarranted.

This article has also contributed to that literature by applying a framework for evaluating the political attributes of generic policy instruments and design features. In doing so, the article also responds to the loudening call (e.g. Fahey and Pralle 2016; Jenkins 2014, 469) for politically pragmatic climate mitigation policy advice that eschews the depoliticised and "first-best" economic methodology adopted in much of the literature on climate policy instruments. This article's insights about the political attributes of restrictive supply-side policies relative to demand-side policies can usefully be combined with existing findings about the political attributes of different instrument-types (market-based mechanisms vs. "command and control" regulation; price vs. quantity instruments) and design features (e.g. revenue allocation strategies, where applicable). Such a combination, for example, suggests an especially strong political case for using quantity-based "command and control" regulation to ban or restrict the supply of coal by new entrants, i.e. a ban/moratorium on new coalmines. It also suggests that supply-side market mechanisms have some distinctive political advantages over similar demand-side instruments.

Future work could fruitfully extend our analysis in three directions.

First, we have been largely silent on the ways in which, and degrees to which, the generic political benefits of supply-side climate policies might *vary* across different contexts (e.g. cross-nationally). Future research on the prospects for supply-side policies in specific countries/regions, and comparative analysis, would be valuable.

Second, we have only minimally discussed the extent to which the relative strengths of supply-side policies vary among fossil fuel-types. Some of the benefits discussed are likely to apply especially strongly to coal, though may apply less strongly to oil and gas. Future research could valuably explore the relative significance of our arguments for the different fossil fuel types.

Third, we have not considered interactions between climate policy instruments. At the very least, future economic analysis of instrument interaction should take into account the efficiency considerations raised in Section 3 of this article. Even more useful, however, is the emerging

[7] For details on how countries could include supply-side policies in their Nationally Determined Contributions, see Piggot et al (2017).

literature on policy instrument interactions that "endogenises" *political* constraints. An insight from recent literature on policy feedback effects is that overcoming political constraints to ambitious climate mitigation is best done by *sequencing* policies in such a way as to engineer feedback effects that expand the politically feasible set of climate policies over time (see esp. Jordan and Matt 2014; Meckling et al. 2015; Urpelainen 2013). Our analysis suggests that supply-side policies are likely to have considerable positive feedback effects, such as the potential to mobilise supportive political constituencies domestically and to foster cooperation internationally (see Section 4). If this is correct, then supply-side policies would be prime candidates to be adopted relatively early in the sequence of policies in a country's decarbonisation pathway. Further examination of these issues would be of great value.

While we hope that policymakers and reformers take these insights about sequencing seriously, we recognise that climate politics is contested, messy and fluid; making progress will require creativity, agility and pragmatic opportunism whenever, and wherever, a "policy window" (Kingdon 2014) opens. Some windows will be more amenable to one type of instrument than to another. Politically successful reformers and interest groups recognise the variety of instruments that can contribute, in different ways, to their desired long-term goal; they draw from the policy toolkit the tool that best suits the political circumstances. The public health/anti-tobacco movement, discussed in Section 2, offers an instructive model in this regard. In our experience, the climate policy community has for too long been excessively narrow in its preference for certain kinds of policy instruments (carbon taxes, cap-and trade), largely ignoring the characteristics of such instruments that affect their political feasibility and feedback effects. At the very least, then, we hope we have shown that supply-side policies should be *in* the toolkit, ready to be wielded when circumstances favour.

Better, we think, to cut with *both* arms of the scissors.

References

Ansolabehere S, Konisky DM (2014) Cheap and clean: how Americans think about energy in the age of global warming. MIT Press, Cambridge

Bell RG, Ziegler MS, Blechman B (2012) Building international climate cooperation: lessons from the weapons and trade regimes for achieving international climate goals. World Resources Institute, Washington, DC

Bellassen V et al (2015) Monitoring, reporting and verifying emissions in the climate economy. Nat Clim Chang 5(4):319–328

Bomberg E (2012) Mind the (mobilization) gap: comparing climate activism in the United States and European Union. Rev Policy Res 29(3):408–430

Cai B, Cameron TA, Gerdes GR (2010) Distributional preferences and the incidence of costs and benefits in climate change policy. Environ Resour Econ 46(4):429–458

Chapman S, Wakefield M (2001) Tobacco control advocacy in Australia: reflections on 30 years of progress. Health Educ Behav 28(3):274–289

Chayes A, Chayes AH (1991) Compliance without enforcement: state behavior under regulatory treaties. Negot J 7(3):311–330

Chubb P (2014) Power failure. Black Inc., Melbourne

Collier P, Venables AJ (2015) Closing coal: economic and moral incentives. Oxf Rev Econ Policy 30(3):492–512

Collins K, Mendelevitch R (2015) Leaving coal unburned: options for demand-side and supply-side policies. DIW, Berlin

Cook BJ (2010) Arenas of power in climate change policymaking. Policy Stud J 38(3):465–486
Denniss R (2008) Fixing the floor in the ETS: the role of energy efficiency in reducing Australia's emissions. The Australia Institute, Canberra. http://www.tai.org.au/sites/defualt/files/fixing_the_floor_in_the_ets_7.pdf
Drews S, van den Bergh CJM (2015) What explains public support for climate policies? A review of empirical and experimental studies. Clim Pol 16(7):855–876
Edenhofer O, Kalkuhl M (2011) When do increasing carbon taxes accelerate global warming? A note on the green paradox. Energy Policy 39:2208–2212
Erickson P, Lazarus M, Tempest K (2015) Carbon lock-in from fossil fuel supply infrastructure. Stockholm Environment Institute, Seattle
Fahey BK, Pralle SB (2016) Governing complexity: recent developments in environmental politics and policy. Policy Stud J 44:S28–S49
Goulder LH, Parry IWH (2008) Instrument choice in environmental policy. Rev Environ Econ Policy 2(2):152–174
Green F (2018) Anti-fossil fuel norms. Climatic Change. https://doi.org/10.1007/s10584-017-2134-6
Guber DL (2003) The grassroots of a green revolution: polling America on the environment. MIT Press, Cambridge
Haas PM (1992) Banning chlorofluorocarbons. Int Organ 46(1):187–224
Harrison K (2012) A tale of two taxes: the fate of environmental tax reform in Canada. Rev Policy Res 29(3):383–407
Harrison K (2015) International carbon trade and domestic climate politics. Glob Environ Polit 15(3):27–48
Helm D (2005) Economic instruments and environmental policy. Econ Soc Rev 36(3):205–228
Hepburn C (2006) Regulation by prices, quantities, or both: a review of instrument choice. Oxf Rev Econ Policy 22(2):226–247
Hughes L, Lipscy PY (2013) The politics of energy. Annu Rev Polit Sci 16:449–469
Jenkins JD (2014) Political economy constraints on carbon pricing policies: what are the implications for economic efficiency, environmental efficacy, and climate policy design? Energy Policy 69:467–477
Jordan A, Matt E (2014) Designing policies that intentionally stick: policy feedback in a changing climate. Policy Sci 47(3):227–247
Kameda T et al (2014) Asbestos: use, bans and disease burden in Europe. Bull World Health Organ 92(11):790–797
Karplus VJ (2011) Climate and energy policy for U.S. passenger vehicles: a technology-rich economic modeling and policy analysis. PhD dissertation. MIT. http://globalchange.mit.edu/files/document/Karplus_PhD_2011.pdf
Keohane NO, Revesz RL, Stavins RN (1998) The choice of regulatory instruments in environmental policy. Harv Environ Law Rev 22(2):313–367
Kerr S, Duscha V (2014) Going to the source: using an upstream point of regulation for energy in a national Chinese emissions trading system. Energy Environ 25(3):593–612
Kingdon JW (2014) Agendas, alternatives and public policies, 2nd edn. Pearson, Harlow
Kuch D (2015) The rise and fall of carbon emissions trading. Palgrave Macmillan, Basingstoke
Lazarus M, Erickson P, Tempest K (2015) Supply-side climate policy: the road less taken. Stockholm Environment Institute, Seattle
Marshall A (1890) Principles of economics. MacMillan & Co, London
Meckling J, Kelsey N, Biber E, Zysman J (2015) Winning coalitions for climate policy. Science 349(6253):1170–1171
Needleman HL (2000) The removal of lead from gasoline: historical and personal reflections. Environ Res Sect A 84:20–35
Newell P, Paterson M (1998) A climate for business: global warming, the state and capital. Rev Int Polit Econ 5(4):679–703
Piggot G, Erickson P, Lazarus M, van Asselt H (2017) Addressing fossil fuel production under the UNFCCC: Paris and beyond. Stockholm Environment Institute, Working Paper 2017-09
Rabe BG (2010) The aversion to direct cost imposition: selecting climate policy tools in the United States. Governance 23(4):583–608
Rabe BG, Borick CP (2012) Carbon taxation and policy labeling: experience from American states and Canadian provinces. Rev Policy Res 29(3):358–382
Seto KC et al (2016) Carbon lock-in: types, causes, and policy implications. Annu Rev Environ Resour 41:425–452
Sinn HW (2008) Public policies against global warming: a supply side approach. Int Tax Public Finance 15(4): 360–394
Sinn HW (2012) The green paradox: a supply-side approach to global warming. MIT Press, Chicago
Skocpol T (2013) Naming the problem: what it will take to counter extremism and engage Americans in the fight against global warming. https://grist.files.wordpress.com/2013/03/skocpol-captrade-report-january-2013y.pdf
Somanathan E, Sterner T, Sugiyama T (2014) National and sub-national policies and institutions. In: Edenhofer O et al (eds) Climate change 2014: mitigation of climate change. Contribution of working group III to the

fifth assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge, pp 1141–1206
Urpelainen J (2013) A model of dynamic climate governance: dream big, win small. Int Environ Agreements Polit Law and Econ 13(2):107–125
van der Linden S, Maibach E, Leiserowitz A (2015) Improving public engagement with climate change: five 'best practice' insights from psychological science. Perspect Psychol Sci 10(6):758–763
van der Ploeg F, Withagen C (2012) Is there really a Green Paradox? J Environ Econ Manag 64(3):342–363
Victor DG (2011) Global warming gridlock: creating more effective strategies for protecting the planet. Cambridge University Press, New York