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Sequencing in Climate Policy to Ratchet Up Stringency Over Time

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Abstract

A major outcome of the Paris climate agreement is the aspirational goal of greenhouse gas (GHG) neutrality. How and through which policy pathways can this be realized? Economists stipulate dynamically cost-effective pathways with rising carbon prices over time. Yet pricing expands slowly in the face of various barriers, while some success is found in different policy trends. We outline a theory of change to overcome barriers to carbon pricing with path dependency and sequencing at its core. The mechanism involves second-best policies that compromise on cost-effectiveness at earlier stages to pave the way for more stringent and cost-effective policies later. We observe California and Germany to identify how policy barriers have been addressed in a sequential manner. We hypothesize that long-term success hinges on building coalitions, reducing costs, avoiding bad policy lock-ins, and other dynamic factors. We hope this framework stimulates a new research agenda of practical value.

Key Words: climate policy barriers, sequencing, coalitions, distribution, governance

JEL Codes: Q54, Q58, D78

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Contents

1. Introduction

A major outcome of the Paris climate agreement was to establish the aspirational goal of greenhouse gas (GHG) neutrality for every signatory in the second half of this century in order to limit global warming to below 2°C. This turns the focus of policymaking from what should be done to how to do it. Given that nationally determined commitments to policies are as yet insufficient to achieve this goal (UNEP 2016), the question is, how and through which policies and processes, at multiple levels of governance, can this goal be realized?

Most economists have advocated carbon pricing as a preferable instrument for climate policy. Some would argue further that it is a necessary instrument to constrain the cost of the policy and thereby enable goals to be realized. Nonetheless, its actual role thus far remains limited.[1] Instead, policy mixes are dominated by directed technology policies, including standards, financing, and deployment policies. Informal pricing is observed as well, such as tradable emissions rate performance standards or renewable energy portfolio standards that use prices to allocate resources but do not directly put a price on carbon. Carbon pricing advocates have some concern that these policies crowd out carbon pricing, as well as skepticism that these policy mixes will expand at a pace that is sufficient to achieve the ambitious Paris goal.

The core hypothesis of this paper is that various barriers to stringent climate policy and an expanded role for carbon pricing exist, and these would first need to be removed or at least relaxed. The barriers we describe include high cost and lack of cost-effectiveness, the presence of a blocking political constituency or absence of advocates with an economic interest in the goal, inadequate institutions and governance, and incomplete coordination across jurisdictions leading to free riding, leakage, and competitiveness concerns. We do not claim this list to be comprehensive; other barriers could be described as well.

From a pragmatic perspective, these barriers might be overcome through a sequence of policies including nonprice and informal pricing policies or a limited application of carbon pricing, incrementally advancing a climate policy regime and enabling what we call dynamic “ratcheting up.” However, as we discuss below, such policies may actually divert policy away from the introduction of carbon pricing or, if they are especially pernicious, lead to a policy failure. Hence, one focus of this paper is to critically consider the role for nonprice policies in a dynamic setting. A particularly useful approach is to employ the concept of sequencing, recognizing that policies that might eventually be essential to achieve high stringency, such as carbon pricing, cannot—or can only in a limited way—be implemented at an early stage because of barriers we describe. Importantly, these barriers might be overcome through the effects or reforms of earlier-stage policies. This implies the potential need for a sequence of policies that may change over time, in which each stage is conducive to achieving the subsequent more stringent one, and potentially one that increasingly embodies attributes of carbon pricing. Presumably, depending on the barriers in place, there might be multiple routes by which to break out of a particular situation of constrained policymaking.

[1] In 2016, about 13 percent of global greenhouse gas emissions were covered by emissions pricing schemes, primarily emissions trading systems (ETS). In 2017, this is expected to grow to 20–25 percent with the addition particularly of a national ETS in China. The price levels of these policies vary widely and are generally not stringent (World Bank, Ecofys, and Vivid Economics 2016).

The idea of sequencing in climate policy is neither new nor without risks, and while it may be essential to achieving the policy goal, it is largely unexplored. Sorrell and Sijm (2003), for example, acknowledge that the timing of instruments matters but do not explicate when and how. Recently, political scientists have started to rigorously explore sequencing in climate policy. Meckling et al. (2015) argue that green industrial policies can help build "winning coalitions" for carbon pricing over time, and similar lines of argument have been developed by Levin et al. (2012), Urpelainen (2013), Keohane and Victor (2016), and Biber et al. (Forthcomming).

Yet the sequencing process remains poorly understood, and the related theoretical literature on path dependency provides only general guidance. In particular, Pierson (Pierson 2000, 253) identifies potential path inefficiency, saying that "in the long-run, the outcome that becomes locked in may generate lower pay-offs than a forgone alternative would have."[2] Accordingly, if sequencing embodies the adoption of knowingly flawed policies at an early stage, the process may pose the possibility of a "bad" lock-in to inefficient pathways, which would prevent rather than enable future ratcheting up of climate policies. Pierson also discusses mechanism for exiting inefficient paths, the most important of which is learning, which could lead to revision of an inefficient pathway. Important in that regard is monitoring, because it can facilitate the linkage of actors' decisions over time; this is an essential precondition for learning. Potential learning notwithstanding, this nevertheless begs the question as to whether nonincremental leaps to a new policy regime without such a danger of lock-ins might be a more promising approach. Pierson acknowledges that "governments may at times be in a position to orchestrate a 'jump' from one path to another" but argues that such events are rare (Pierson 2000, 262).

In this paper, we employ the working hypothesis that sequences conducive to increasingly stringent policies are possible, providing interim achievements while remaining consistent with or enabling the achievement of ambitious long-term policy goals. Our optimism partly rests on historical experience such as that documented by Hanemann (2008) regarding California's adoption of legally binding GHG emissions goals. However, we remain cognizant that policy sequences could fail to achieve the desired objective and return to this concern later.

We go beyond previous work by developing a heuristic to describe ratcheting-up sequences, from which we derive a research agenda. In the first step, we develop a conceptual model comprising a categorization of different barriers and related policy sequencing possibilities drawing on the literature. In the second step, we use this model to consider what may be empirical examples of ratcheting-up policy sequences in California and Germany, arguably two of the world's most advanced jurisdictions in terms of climate policy and thus two potentially rich cases to investigate. These examples are, first of all, observations to underpin—or question—our conceptual framework, and in that regard they are also instrumental in identifying further research questions.

A refined understanding of policy sequencing will be of both theoretical and practical use. From a theoretical perspective, this project contributes to the development of a dynamic theory of climate policy change.

[2] In a recent related paper, Fouquet (2016) cautions about the risks when economies lock in to energy-intensive pathways.

An element of the analysis involves the dissection of policies into their component characteristics or attributes, which themselves might evolve or be recombined in new policies. For example, the infusion of regulations with flexibility over time may enhance their cost-effectiveness and help overcome the cost barrier. The theoretical effort in a dynamic context builds toward an understanding of the policy design space beyond stylized textbook instruments.

From a practical viewpoint, the study provides a starting point from which to address questions such as the following: Do we simply need more of the same policies? That is, will current approaches dominated by policies supporting specific technologies prevail so that they can just be scaled up, or do we need something different, such as ambitious carbon pricing? Can we identify previously successful sequencing options to build a tool kit of approaches that might be pursued in different contexts? And can we identify the conditions under which they have been successful, as well as possible risks and side effects?

The rest of this paper is structured as follows: In Section 2, we develop the conceptual framework and identify main barriers to increasing policy stringency. In Section 3, we characterize the barriers, drawing on the economics and political science literature, and look for sequencing that may have occurred in Germany and California. In Section 4, we review these observations and formulate elements of a new sequencing research agenda.

2. Conceptual Model

In this section, we propose a conceptual model featuring two core elements to explain how sequences of policymaking might lead to greater policy stringency or broader scope over time. First, we conceptualize various *barriers* that limit stringency or scope.

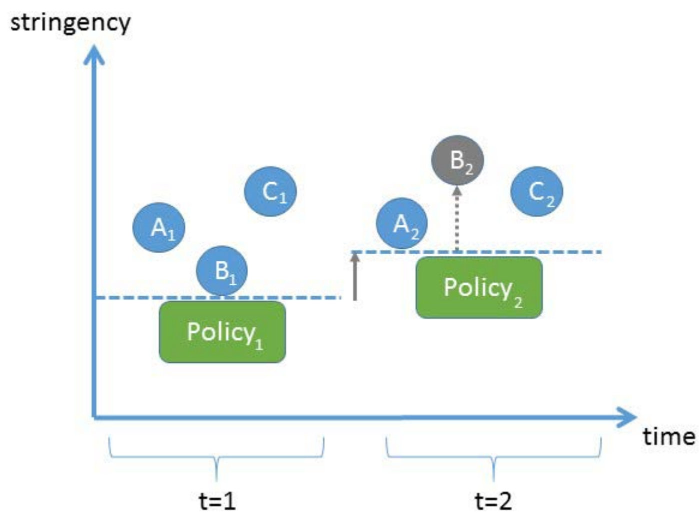
Second, we conjecture a *sequence* of policies that involves *feedback* in policymaking. At the core of policy feedback is the notion that it can relax barriers to policy stringency or scope (Moynihan and Soss 2014; Kelsey 2014). Policies can also affect other contextual factors, such as the rate of technological innovation, investment, and consumer behavior. In other words, policy enacted in a first stage (T = 1) of policymaking can affect the potential for more stringent policymaking in subsequent stages (T = 2, …). Note that such processes are initiated at all stages, and the choice of which stage is the first one is arbitrary.

Bringing both elements together, we theorize that policy feedback processes may enable policymaking to relax or remove barriers, thereby allowing increasing stringency as illustrated in Figure 1. More formally, we use the following working definitions: A *ratcheting-up sequence* is a series of policymaking phases in which the effects of policy made at an initial stage (T = 1) enable or induce changes to its context (e.g., institutions, political economy, technologies) that effectively overcome barriers to higher stringency. In consequence, a policy can become more stringent at a subsequent stage (T = 2) in terms of key design parameters (e.g., level of carbon price or standard, volume of subsidies) and amount of induced emissions reductions. By extension, a *ratcheting-out sequence* is a series of policymaking phases in which the effects of policy at T = 1 make it possible to implement broader policy, covering additional sectors, issue areas, or jurisdictions.

Barriers to more stringent mitigation policies can be characterized in many ways. Based on our observations and the literature, we propose a not necessarily comprehensive taxonomy of four broad major categories that will often interact:

- **Cost:** Costs are expected to increase as ambition increases and costlier mitigation options need to be deployed; if costs increase steeply with greater ambition, cost-effective policy design and reductions in the costs of low-GHG technologies can be expected to become increasingly relevant.
- **Distributional dynamics:** Incumbent groups usually have an economic interest in the status quo. Building powerful new constituencies with an economic or social interest in the aspirational policy outcome can be expected to be important for policy success.
- **Institutions and governance:** Legal and policymaking structures and regulatory agency capacities and procedures may not be well developed or trusted or may limit the implementation of certain policy options. Capacity building and institutional reform will often be required before more stringent policy is implemented.
- **Free riding:** Efforts by one jurisdiction are undermined and made more expensive by leakage to other jurisdictions with less stringent policies. Effective measures to counteract such effects of unilateral action may be essential to enable higher stringency.

FIGURE 1. SEQUENCING TO OVERCOME BARRIERS TO STRINGENCY



Note: Barriers (blue circles) and climate policy (green rectangles) stringency are shown for two subsequent periods ($t_{1,2}$). Relaxation of the most stringent barrier (here, B_1) enables increased policy stringency over time, to the level of the new most stringent barrier (A_2).

In practice, in a specific political context, multiple barriers are often entangled. Indeed, it is often possible to conceptualize the "same" barrier in multiple ways, and different conceptualizations can suggest different strategies for designing and implementing policies and related processes to relax barriers. Hence, the typology should be seen as a way of disciplining the conceptualization rather than as a rigid framework with strictly exclusive categories.

Three aspects of this model require further discussion. First, if there were only one barrier, then the most efficacious policy strategy seemingly would be to address that barrier directly. However, the presence of multiple barriers implies that policy strategy might need to consider which to address first. This might also require temporarily ignoring some barriers if they cannot be effectively addressed. By analogy to mathematical economics, in the presence of multiple barriers (constraints), care needs to be taken that policy aiming to remedy one barrier does not worsen the situation with respect to others. We borrow terminology from economics (Lipsey and Lancaster 1956) to describe this as a "second best" policy setting, wherein the remedy to one barrier may fall short of a conceptual ideal because of interaction with other barriers. For example, the cost of a policy may invite more cost-effective measures, such as carbon pricing. But in the face of international free riding or mistrust of political institutions, policy that intentionally increases the price of fossil energy goods or mobilizes a transfer of substantial value may amplify leakage or erode political support for policy stringency. Indeed, an exact specification of the actual second best including all relevant barriers is enormously challenging, and with incomplete or misguided specifications, in principle anything can happen. We define successful strategy as moving forward in addressing at least one barrier without sliding backward with respect to others, possibly causing the path to the aspirational goal to often be circuitous, possibly ratcheting out to address a different sector before returning to prior areas. It is obviously very challenging to determine whether backsliding occurs, and we will come back to this issue in the concluding section.

Second, the model is agnostic as to whether policy changes (a) are brought about intentionally by policymakers in response to or in anticipation of barriers, (b) are intentional but undirected and circumstantial, or (c) are unintentional and virtually accidental. An example of an intentional and directed policy consequence might be to achieve economy of scale in production of low-carbon technologies to reduce their costs. An intentional undirected policy objective might be to promote learning from policy experimentation that spills over to other domains. If the process was intentional and directed, one would expect sequencing to take the form of a strategic series of causally related policy reforms; if the process was undirected or unintended, one would expect sequencing to take a more erratic or "serendipitous" form. Later examples will show that actual policy sequences appear to contain both elements.

Third, to make this model analytically useful, it is important to clearly identify the distinct stages, the point of transition between them, and the factors that enabled it. Pierson (2000) refers to this as the necessity of focusing on branching points and the specific factors that reinforce or alter the path. This is of crucial importance to make a proper sequencing argument and avoid ad hoc explanations such as "one event just happened to follow another." In the context of the model developed here, it would be necessary to explain (a) the existence of a barrier, (b) how exactly earlier policies contributed to overcoming it, and (c) that as consequence, a more stringent policy was implemented (at some branching point). In practice, however, it is very challenging to rigorously establish such clear causal relationships.

3. Barriers to Stringent Policies and Sequencing Options to Relax Them

In this section, we characterize the four policy barriers introduced above and policy sequencing processes through which they might be overcome. We illustrate each with examples from experiences in Germany and California, and then formulate questions for further research.

3.1. Cost

Characterization: Cost may not be a decisive barrier early in the development of climate policy, and cost-effectiveness may not be a crucial policy design criterion initially. But greater stringency of the aspirational GHG reduction goal will likely involve higher costs, which may erode the coalition that supported the initial policy and by extension endanger its durability (cp. Patashnik 2008; Rabe 2016). It thus appears that developing low-cost technologies, as well as cost-effective policy design, is essential to enable increasing stringency (which, for achieving the 2°C goal, will eventually require achieving global net zero emissions). Accordingly, in case initial technology costs are high or policy design is cost-ineffective, reductions in technology costs and subsequent policy reforms enhancing cost-effectiveness will be instrumental.

We distinguish two notions of costs: First, *technology costs* refers to the overall costs of low-GHG technologies, regardless of the cost-effectiveness of policy design. For example, the costs of renewable energies—which are central for decarbonization—have dropped significantly over the past decade, as technologies have learned. A second notion of costs relates to the *cost-effective design of policies*. For example, technology-specific standards will usually be less cost-effective policy tools than those offering more flexibility, such as tradable standards (Sterner 2012). Accordingly, policy design is related to the efficient choice and use of technologies and respective cost reductions.

The economic literature on climate policy design offers a number of relevant insights on what might be the cost-effective policy pathway over time, synthesized for example in chapter 15 of the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Somanathan et al. 2014). In the absence of market failures or barriers, long-term carbon pricing is considered the most cost-effective policy (Goulder and Parry 2008). One strand of literature finds that in the presence of technology market failures and barriers, intertemporal policy costs can be minimized with policies that complement carbon pricing aimed at technology research, development, and deployment to ensure that technologies are developed in time to minimize costs along a policy pathway (Jaffe, Newell, and Stavins 2005). The analyzed market failures and barriers are typically transient—that is, the decrease in magnitude and eventually vanish over time—suggesting that technology policy should be equally transient (Gillingham and Sweeney 2010; Kalkuhl, Edenhofer, and Lessmann 2013). A related strand of literature considers path dependency that disadvantages innovation in clean technologies and creates a bias toward the dirty capital base (Acemoglu et al. 2012). This can be corrected through interventions that redirect innovation and investments toward clean inputs, which also need only be temporary until a new technology emerges as dominant. Some have argued, however, that such interventions need to be persistent (Lemoine 2016).

A second strand of literature specifically relates to interactions of new regulations or taxes with preexisting instruments, with implications for technological innovation and policy cost over time. In recent work, Goulder et al. (2016) compare clean energy standards (CES) with cap and trade (C&T) in what they call “a realistic economy” with preexisting taxes on production factors. They find that for moderate stringency, CES are more cost-effective than C&T because they give rise to a smaller tax-interaction effect (i.e., policy-induced distortion of factor markets). Fischer (2016) finds a similar result demonstrating that the relative advantage of carbon pricing is diminished in the presence of potential leakage of economic activity to jurisdictions that are not regulating carbon. In both cases, with policy stringency increasing over time and assuming jurisdictions introduce comparable carbon prices as well (see free riding below), the direct-cost disadvantages of carbon pricing relative to directed technology policies then decrease and eventually make it the most cost-effective policy option.

Policy sequencing options: Assuming the existence of barriers to realizing the dynamically cost-effective policy path, sequencing may allow a gradual decrease of technology cost and increase in cost-effectiveness of policy design. There seem to be three sequencing options to address cost barriers. First, through the use of dedicated green technology (industrial) policies, initially very high technology costs could be driven down. However, following the above literature, once targeted technologies are fully developed, the cost-effective pathway would be to phase them out and at the same time to phase in and increase the level of economy-wide carbon prices over time. The ability to terminate or phase out a technology policy may be influenced by the policy design, which alludes to the second sequencing option, in which individual policies with low cost-effectiveness such as prescriptive regulation can be gradually infused with incentive-based approaches such as market or pricing mechanisms (e.g. Burtraw 2016; Pahle and Schweizerhof 2016). Third, pricing policies with limited sectoral or technological coverage can be broadened to more comprehensive coverage so as to equalize marginal costs across all sectors. Table 1 provides an overview of sequencing options to reduce costs as a barrier to policy stringency.

TABLE 1. SEQUENCING OPTIONS FOR COST BARRIERS

Specific barrier	Sequencing options
High technology costs	Drive down technology costs through dedicated green technology (industrial) policies
Lack of policy cost-effectiveness	Phase in more cost-effective policies: • Phase out technology policies once technologies are mature, such as through sunset clause • Infuse regulation with incentives, ultimately reaching carbon pricing (first-best) • Increase sectoral coverage of policies

Observations: The most evident example of increased climate policy stringency in both California and Germany is the scaling up of respective renewable targets. At the beginning of the 2000s, both jurisdictions set targets of a 20 percent share for renewables in electricity consumption and procurement by 2020. In the late 2000s, these targets were revised and increased to 33 percent and 30 percent, respectively. In 2012, Germany adopted the Energiewende legislative package, which extended the existing 2020 goal even further into the future to at least 80 percent in 2050. Most recently, in 2015 California adopted SB 350, which extended its goal to 50 percent in 2030.

At the beginning of this development technology costs were very high, in particular for solar photovoltaics that for example in Germany required support of around 500 €/MWh in 2000. But technology costs were already then recognized as a temporary barrier: it was an established fact that renewable technologies undergo considerable learning effects that drive down technology costs over time. At the same it was clear that these reductions would need to be actually realized in the future to make the technologies economically viable. Against that background, driving down these costs was a core rationale for renewable support in Germany and an explicitly formulated goal in the underlying legislation. The main approach for doing so—and thus one of the main design consideration for the support scheme—was to create a protected niche market, which allowed technologies to develop and developers to learn. This proved to be successful, again especially for solar photovoltaics and to some extent also for other technologies (e.g. onshore wind) – even though costs reduction by now are largely driven by the global markets. Cost for large scale solar PV installations are by now down to around 7 €/MWh[3]. Accordingly, this development has considerably relaxed the technology cost barrier by bringing down the costs of renewables in the power sector to a level close to fossil technologies (Edenhofer et al. 2014). This was very likely an essential requirement to put into law the vision of renewable based energy system (Energiewende) in 2011 and ratcheting up of renewable targets.

In California, renewable costs have seen similar cost reductions. The falling costs of photovoltaic (PV) solar and wind have been driven by both global market trends and programs such as the California renewable portfolio standard, enabling the state to meet its increasingly stringent targets. The national median installed price for utility-scale solar PV has fallen almost 60 percent since 2007–9 to $2.70 per watt of installed capacity (alternating current) in 2015. The 2015 median installed price in California was $2.70 per watt, slightly higher than the national median (Bolinger and Seel 2016). Similarly, the national capacity-weighted average installed project cost of wind has declined about 27 percent from the 2009–10 peak to $1.69 per watt in 2015 (Wiser and Bolinger 2016). The lower costs of these renewable resources have made them increasingly competitive with fossil fuels in California, and the program has ratcheted up a series of increased targets since its establishment. The current statutory goal is 50 percent renewables by 2030 in the electricity sector.

3 Source: https://www.bundesnetzagentur.de/DE/Sachgebiete/ElektrizitaetundGas/Unternehmen_Institutionen/ErneuerbareEnergien/PV-Freiflaechenanlagen/Beendete_Ausschreibung/Beendete_Ausschreibungen_node.html;jsessionid=A80EDFA5EFADB2C9F05389B2E1D35FB6

An important difference exists between California and Germany concerning cost-effectiveness of renewable policy instruments. While California used a quantity-based approach in the form of a renewable portfolio standard (RPS) from the very beginning, Germany, drawing on previous policy experience, used a direct financial incentive in the form of a feed-in tariff. Implemented in 2000, the feed-in tariff was primarily tailored to remove market risks for renewables through long-term fixed price power purchase agreements with a guaranteed grid connection and power uptake—the so-called priority feed-in (Mitchell, Bauknecht, and Connor 2006). Moreover, deployment was not capped by setting a maximum of new projects (capacity) per year. Initially, overall support costs were relatively low compared with power prices, and cost-effectiveness was not a great concern. However, after a surge of deployment mostly of relatively costly solar PV, the German Renewable Energy Sources Act (EEG) ran into a "cost crisis" when the electricity price surcharge to pay for the policy was raised from 35.9 €/MWh in 2012 to 52.7 €/MWh in 2013, leading to substantial public criticism. German policymakers responded by reforming the feed-in tariff to a sliding premium (2014 reform), the level of which will be determined in auctions from this year on (Pahle and Schweizerhof 2016). It seems very likely that this sequence of reforms enhancing policy cost-effectiveness was essential for sustaining the ratcheting up of renewable deployment henceforth.

In California, an increase of cost-effectiveness in policy design over time can also be observed in the evolution of the overall policy mix. California's first major climate policy (AB 1493) was enacted in 2002 and specifically targeted emissions from new motor vehicles. Building on past positive experience with the state's 1988 Clean Air Act, the implementation of AB 1493 relied on regulation in the form of tradable fleet emissions (technology) standards (Hanemann 2008, 14–15), a relatively ineffective design option because it is not technology neutral. According to Bedsworth and Taylor (2007), the California Air Resources Board's overestimation of advanced technology and underestimation of conventional technologies in setting the standards resulted in an overly complex program and a weakened demand signal for zero-emissions vehicles. However, this changed with AB 32, enacted in 2006, which implemented a more flexible low carbon emissions intensity standard for fuels that called for a 10 percent reduction in the GHG content of transportation fuels by 2020, which could be achieved in a variety of ways. The state also implemented an economy-wide cap-and-trade scheme—not as the only policy, but as an important backstop measure to ensure that emissions targets will be reached. In contrast to Germany, cost-effectiveness was not increased as a result of a "cost crisis" but emerged from the Climate Action Team's recommendation to have a "multi-sector, market based system " (Hanemann 2008, 7). Therefore, it is probably not so such much an example of a ratcheting-up sequence, but rather a ratcheting-out sequence involving increasingly broad sector coverage of climate policies.

The broader question for sequencing is how to advance existing policies in the direction of the first best. Of special importance is the timing and interaction of technology policies and carbon pricing, and how policy design can facilitate the transition from the former to the later over time.

3.2. Distributional Dynamics

Characterization: While aggregate costs can constitute an important barrier to climate policy stringency, the distribution of these costs (as well as benefits) across constituencies will be decisive for political feasibility.

In what might be coined the "folk theorem" of the political economy of environmental policy, building on work by Olson (1971) and Stigler (1971), Oye and Maxwell (1994) stipulate an important barrier to policy stringency if, for a given policy design, costs are borne by concentrated and well-organized groups (such as energy-intensive industries in the present) while policy benefits are widely diffused (e.g., globally and across generations). In that case, a veto coalition will be relatively easier to organize than a supporting coalition. Conversely, policy design conferring benefits to concentrated and well-organized groups while diffusing costs across the wider population will facilitate building a supportive coalition (Wilson 1980).

Policy sequencing options: A first set of options to overcome adverse distributional configurations would be to focus on creating winning coalitions by providing concentrated benefits that can build support for carbon policies. Accordingly, policy can initially aim primarily at creating constituencies—for instance, by supporting interest groups such as renewable energy industries through subsidies and other payments (Biber, Kelsey, and Meckling Forthcomming), which arguably might eventually form a winning coalition for carbon pricing at a later stage (Meckling et al. 2015).[4] In that way, policy would focus on enabling ratcheting up of ambition later on, rather than primarily aiming at direct emissions reductions (Levin et al. 2012).

Sequencing options for addressing political economy barriers can also aim at relaxing political resistance by groups bearing significant and concentrated costs, such as if their business models or jobs are threatened. This can be done through targeted exemptions and compensation to get consent (e.g., Jenkins 2014), such as through grandfathering of certificates or rebates on carbon fees (Burtraw and Sekar 2014). At the initial stage of climate policy implementation, options to do so can involve differentiation of regulatory stringency, limited initial sectoral coverage, or compensatory measures. More broadly, such measures can help fragment political opposition and make it easier to overcome distributional barriers (Bettzüge 2016).

There is an underlying conflict between economists and political scientists such that there is a trade-off between deploying policies maximizing cost-effectiveness in policy design over time (Table 1) and distributing costs and benefits strategically across different societal groups to maximize stringency (Table 2). Economists tend to be concerned that cost-ineffective policy design will reduce welfare and that policies that are costly on aggregate will also be difficult to ratchet up over time. A specific concern in that regard is the creation of constituencies through any forms of subsidies. Subsidies are generally difficult to reverse through subsequent policy reforms, which may lead to a "bad lock-in" in the sense that this can counteract the increase of the cost-effectiveness of the overall policy mix. By contrast, political scientists tend to emphasize that while perhaps not first best from a cost-minimization and welfare perspective, policies strategically addressing the creation and management of supportive and opposing policy coalitions may enable more stringent (and thus eventually welfare enhancing) policy over time with respect to distributional barriers.

[4] Another option not directly related to policy is the development and adjustment of compelling policy narratives over time (Leipprand, Flachsland, and Pahle 2016).

TABLE 2. SEQUENCING OPTIONS FOR DISTRIBUTIONAL DYNAMICS BARRIERS

Specific barrier	Sequencing option
Opposition by regulated interest groups	Use targeted exemptions and compensation to get consent, such as grandfathering of certificates Employ sectoral differentiation, such as policies with lower stringency (or more compensation) in sectors with higher political opposition
Lack of supporting coalition	Prioritize policies (e.g., green industrial policies) that expand supporting population and constituencies Counteract regressive effects with complementary policies and programs

Ideally, smart sequencing options would aim at relaxing or even removing such trade-offs over time. The primary interpretation of distributional concerns from carbon pricing, for example, has focused narrowly on the incidence (distribution of costs) of the policy or environmental justice issues. Carbon pricing with strategic allocation of the created value (in terms of allowances, auctioning, or tax revenues) might provide an option that balances a cost-effective incentive to decarbonize with the creation and compensation of constituencies (see above).

Observations: The first set of observations relates to the creation of supporting constituencies. In Germany, the development of the EEG over time illustrates sequencing to address distributional barriers. It was specifically designed to confer targeted benefits to new actors outside the traditional sector—in particular, renewable manufacturing companies and new investors—to overcome the opposition to renewable support by large utilities, which showed great reluctance to change their business models accordingly (Lauber and Mez 2006; Stenzel and Frenzel 2008).[5] This appears to have enabled a "winning coalition" that remains a strong political force in support of the policy.

In California, early moves in the 1960s around air quality, and beginning in the 1970s and 1980s around energy conservation and renewable energy, shaped the interests of groups such as utilities and an early renewable energy industry, and they became increasingly accustomed to policy interventions related to pollution and climate goals. Ultimately, the growth of renewable energy manufacturing and installation, energy-related investment and venture capital, and the movement of utilities toward owning or long-term contracting with renewable energy assets pulled together a coalition of interests that actively supported policymaking for renewable energy and, less directly, carbon mitigation. The renewable energy industry shares a common agenda with

[5] The industrial policy aspect of the EEG was only partly successful. Whereas the wind industry has established itself among top firms worldwide, the solar industry has experienced a dramatic decline in recent years (Pahle, Pachauri, and Steinbacher 2016).

the growing green business industry, which has supported the relatively ambitious set of legislation and played a prominent role in the subsequent defense against a ballot initiative challenge in 2010. The accounting of jobs and economic activity associated with green industries helped galvanize support for the strengthening of binding carbon reduction targets through 2030.

The second set of observations relates to distributional aspects to gain the consent of opposing political groups. In Germany, as the EEG was successful in driving a significant expansion of renewables in the power system, policy costs increased and energy-intensive industries complained about competitiveness risks from rising electricity costs. In response, by 2016, more than 2,100 companies with consumption totaling around 25 percent of total German power consumption had become at least partially exempted from paying the EEG surcharge. While these exemptions have been met by political resistance, such as from the Green Party, they are widely considered to have enabled continued operation of the EEG at a significant level of ambition by evading resistance of the energy-intensive industries. Another factor in that regard is the free allocation of certificates within the European Union's Emissions Trading System (EU ETS) to these industries. Here again, these exemptions might have been essential to gain consent for the prolongation of the EU ETS and the currently negotiated ratcheting up of its linear reduction factor (an annual decrease in the aggregate cap) from 1.74 percent per year to 2.2 percent. Similarly, in the power sector, certificates were also initially grandfathered in the national allocation plan of the first phase of the EU ETS, but auctioning was substituted in later trading periods (Pahle 2010). This is important because it hints at the possibility of revoking such exemptions later on.

In California, the distributional outcomes of environmental policy and the consideration of environmental justice are requisite elements of the policy process. In fact, the environmental justice movement was one of the main opponents of cap and trade in AB 32 because it was concerned about the local air pollution implications that might have affected them disproportionally in "hotspots" (see Hanemann 2008). In 2016, the extension of carbon reduction targets was accompanied by companion legislation that explicitly directed state agencies to address and report on environmental justice concerns.

The broader question for sequencing is which specific distributional options, over time, would enable maximal stringency, and what would be the stringency relative to other policy options.

3.3. Institutions and Governance

Characterization: The existing regulatory and legal institutions within jurisdictions may limit the ability to enact policy because of (a) a lack of expertise or capacity in the relevant government bodies; (b) overemphasis on short-term versus long-term goals in government decision making; (c) veto points that make otherwise preferable policy choices unavailable; and (d) a lack of public participation processes that can increase legitimacy or competence of government decisions.

Climate change is a relatively new challenge for government decisionmakers, and it is a challenge that is daunting in its size and complexity. Governments will have to either create new entities to address the problem or repurpose existing entities; in either case, there will be significant learning curves with respect to designing, implementing, governing, and reforming new policies. Climate change is also fundamentally a problem of managing for the long term, often at the expense of short-term benefits.

However, public decisionmaking processes can be susceptible to political pressure to emphasize the short term, and managing for the long term requires the political process to make credible long-term commitments. All political systems involve decisionmaking structures with one or more veto points; different political systems may have more or fewer veto points and may make certain decisions subject to greater veto points (Biber, Kelsey, and Meckling Forthcomming). For instance, raising taxes at the EU level requires the unanimous support of member states, which was a decisive factor leading the EU to adopt the ETS instead of a carbon tax.[6] Finally, public participation in the government decisionmaking process may improve both competence and legitimacy of the input and output of the process.

Policy sequencing options: Overall fours specific barriers and related sequencing options could be identified; see Table 3. First, building on the expertise of existing institutions, including on the known effectiveness of existing policy instruments, may allow initial policymaking in the climate change arena to be more effective, even if existing institutions and policy instruments may be less than optimal on other metrics, such as cost-effectiveness. Stated another way, the regulator's ideas and ambition may be constrained by the previous experience of regulators even when the policy is evolving away from prescriptive to market-based approaches.[7] Policy learning can also happen through diffusion from other policy domains or from other jurisdictions.

Second, a greater focus on long-term interests might be achieved by reforming political institutions (see Levin et al. 2012) or by creating new institutions designed to explicitly represent long-term interest, such as a carbon central bank (e.g. Grosjean et al. 2016) or—weaker in authority—a climate change committee as in the UK (Lockwood 2013). A less ambitious approach is to use policy tools that are resistant to repeal because of support from entrenched interests (Biber 2013) or because they create long-term property rights that are more difficult to revoke (Brunner, Flachsland, and Marschinski 2012).

Third, policy options may be strategically chosen to avoid veto points until the political support to overcome those veto points has been developed over time. In many jurisdictions, this may require avoiding (significant) carbon pricing until other policy tools have built the political support necessary to overcome the higher veto points for those prices.

Fourth, policies can explicitly include public participation requirements to improve the expertise and legitimacy of decisions. Unintended outcomes, it is argued, are less likely to happen if opportunities are given to every group to articulate its concerns about potential outcomes (Beierle and Cayford 2002). Practitioners describe public process as the quality assurance and quality control of public policy. Public participation also may address opposition based on fairness and concerns of the environmental justice community that have focused on uneven distribution of benefits.

[6] https://europa.eu/european-union/topics/taxation_en. A high-level German policymaker involved in implementing the EU ETS confirmed this in a personal conversation.

[7] This was illustrated in the 1977 Clean Air Act Amendments, which adopted innovations that had been tested in some states.

TABLE 3. SEQUENCING OPTIONS FOR INSTITUTIONS AND GOVERNANCE BARRIERS

Specific barrier	Sequencing option
Lack of expertise and capacity	Build on existing agencies and policy tools doing related work to set up new climate policies Draw on related policy domains or other jurisdictions in designing policies
Long-term versus short-term interests	Create new institutions that are politically insulated or otherwise able to focus on long-term outcomes Implement policies that are resistant to rollbacks (e.g., through creation of property rights) and ensure credible long-term political commitments Codify regulatory actions through legislation; that is, make them legally binding
Veto points	Select initial policy options that face reduced veto points and that can also build political support to overcome more stringent veto points in the future
Public participation	Allow for public notice and comment; hold public hearings for major decisions Allow for judicial review of agency decisions to ensure that public voices are appropriately recognized

Observations: First, in both Germany and California the development of institutional expertise and capacity has been an essential factor to advance environmental policy over time. In Germany, the main governmental body is the German Environmental Ministry (BMUB). It was originally founded after the Chernobyl incident in 1986, with the primary responsibility of nuclear safety; it had little expertise and experience in energy policymaking. This changed in 1991, however, when it became responsible for the need feed-in act (StrG) to support power generation form renewables. This law was the predecessor of the 2000 renewable energy act (EEG), which the BMUB designed based on the positive experiences it had with the StrG and the technical competences its staff had developed alongside. In parallel, the BMUB also became a main actor in advancing the idea of the energy transition. Since mid-2000, the ministry has been commissioning a number of long-term scenarios (*Leitstudien*) intended to demonstrate that a significant share of renewables until the mid of the century is feasible.

These studies have been an important reference point for policy debates and arguably played an important role in the 2011 Energiewende decision. From 2003 on, the BMUB has taken the lead role in developing and implementing the EU ETS, for which expertise and emissions data had to be developed over time, as no other multinational GHG emissions trading currently existed. Implementation of the EU ETS has led to the setup of the German Emissions Trading Authority (DEHst) under the auspices of the Federal Environmental Agency, with about 160 staff. The role of DEHst, however, has so far been mainly restricted to administrative tasks and functions less to actively impact further policy development.

One important feature of California's policy landscape is that air quality and climate policies are housed in a single agency, the Air Resources Board. The agency built a strong institutional foundation over decades of regulating air quality, producing as a legacy an expert technical staff and a successful (although sometimes tumultuous) long-term relationship with the state legislature, which were important factors when it began to develop innovative climate policies (Hanemann 2008). Moreover, the state's agenda for achieving air quality objectives is integrated in planning for the implementation of climate objectives, offering the possibility of greater effectiveness and cost-effectiveness across their mission.

Second, in the context of long-term versus short-term decisionmaking, an important development in both Germany and California is the creation of planning processes and related policy documents to specify and achieve long-term targets. In Germany, the BMUB has initiated several processes to pave the way for more comprehensive and targeted action, perhaps most importantly through the recent Climate Action Plan 2050 (BMUB 2016), which for the first time lays out potential measures to achieve the respective long-term climate targets. The main idea behind it is to accelerate and catalyze the debate about the required policies and prevent postponing decisions to the future. In additions, a major achievement of the plan was a (tentative) sectoral burden-sharing agreement; that is, 2030 climate targets were defined for each sector separately so as to avoid politically contentious mitigation efforts. Similarly, California's climate legislation required the Air Resources Board to develop a scoping plan that describes the approach the state will take to reduce emissions, and it must be updated every five years. The plan provides a comprehensive overview of the regulatory impact on all sectors of the economy.

Also of relevance for long-term decisionmaking, regulatory measures implemented by an executive agency can be undone through subsequent administrative action, whereas repealing legislation requires affirmative action by a legislature, which may be more difficult to do. Accordingly, initial policy steps that are enacted through regulatory measures might be made more durable through later legislative enactment, as has occurred in California. For example, the legislative renewable portfolio standard adopted in 2002 followed earlier policy developed by state agencies. The state's procurement policy precluding long-term contracts for electricity from power plants with emissions rates greater than natural gas combined cycle facilities was initially developed by the California Energy Commission before codification in SB 1368. Regulations to address superpollutants—including methane from agricultural operations and industrial gases—were developed by the board before being codified in SB 1383.

Policy measures can also create strong interest group support that makes subsequent repeal more difficult. As noted above, in California, decades of environmental and energy policies produced increased support among influential interest groups, including electricity utilities and renewable energy companies. That support in turn provided valuable opposition to a 2010 ballot initiative that sought to effectively repeal California's greenhouse gas regulatory system (Biber 2013).

Third, in Germany's political system, the number of veto points at the early stage of policymaking crucially depends on ministerial responsibilities. More specifically, ministerial staff is responsible for drafting new bills or amendments for existing bills, which is typically done in line with the overall objectives of the ministry. Historically, the ministry of economic affairs (BMWi) had been responsible for all forms of energies and primarily promoted industrial and incumbent sectoral interest in that context. When a new government came into power in 1998 with the plan to upscale renewable deployment, BMWi's responsibility thus constituted a kind of "informal" veto point for these plans. To circumvent this barrier, the environmental minister successfully transferred the authority for renewable energy to the BMUB in 2002 (Ohlhorst 2009, 198). In that way, renewable energies became a dedicated priority with basically no veto points on the ministerial level. This transfer of authority was another factor that enabled capacity building within the BMUB (see above).

Fourth, regarding public participation, an aspect of institutional development in California is the emergence of an extensive process for public comment at various stages of regulatory development, as well as explicit outreach to affected communities and web casting the nearly daily public hearings, all of which conveys a sense of procedural fairness (Beierle and Cayford 2002). A particularly insightful example is the cap-and-trade program. In 2006, the state formed an environmental justice advocacy committee, which has monitored the performance of the program and influenced the evolution of policy. The passage of subsequent legislation requires that 25 percent of auction revenue be reinvested in disadvantaged communities, and finally, the passage of AB 197 in 2016, legislation that accompanied the extension and strengthening of the state's carbon emissions reduction goal for 2030, requires that the program achieve emissions reductions at facilities that would yield ancillary air quality improvements that benefit surrounding communities (this is a case where distributional barriers and institutional sequencing options overlap). These constraints challenge the textbook operation of the cap-and-trade program but, we conjecture, contribute to the program's political durability and capacity to ratchet up.

In Germany, public participation has also increased considerably in the last years. The AG Emissionshandel, initiated during the inception phase of the EU ETS and still operating today, features wide industrial and stakeholder participation and exchange on implementation and strategic issues. It is understood to have significantly contributed to building expertise, trust, and legitimacy over time. More broadly, basically all major climate policy-relevant documents now undergo comprehensive consultation processes (e.g., power market and energy efficiency green book). Moreover, the Climate Action Plan 2050 is conceived as a process building on extensive participation of business and civil society. Here again, we conjecture that participation plays an important role for ratcheting up in the sense of building trust, expertise, legitimacy, and related policy support over time.

The broader question for sequencing is the degree to which institutions and governance are essential for ratcheting up and how they need to coevolve with policy, also taking into account aspects like durability.

3.4. Free Riding

Characterization: Concerns over free riding are the prototypical barrier to the adoption of ambitious policy to mitigate greenhouse gases, because successful policy requires that actions be taken across the world. Economists have described this problem as free riding, a multilateral prisoner's dilemma, or a coordination issue (Carraro and Siniscalco 1993; Barrett 2005; Nordhaus 2015). The fundamental characteristic of this barrier is the inconsistent alignment of benefits and costs across jurisdictions (Oates 1968). For example, actions taken by leadership jurisdictions such as California and Germany to reduce emissions yield benefits that accrue to other jurisdictions while incurring costs that are concentrated domestically and, moreover, that lead to leakage of economic activity and emissions to unregulated jurisdictions. This relates to the distributional barriers discussed above but has different properties in terms of the extraterritorial nature of the scope of distributional (and, in fact, institutional and policy cost-effectiveness) implications.

Policy sequencing options: Sequencing options to overcome free riding are often intentional. They include the creation of interjurisdictional institutions such as through the development of the United Nations Framework Convention on Climate Change (UNFCCC) climate regime and the potential linking, or at least coordination, of ETS and other instruments (Flachsland, Marschinski, and Edenhofer 2009; Burtraw et al. 2013; Metcalf and Weisbach 2012; Ranson and Stavins 2016). This might be facilitated by economic transfers that stimulate investment or provide compensation to other jurisdictions. Note that such an approach might also be a way forward in already fully linked cap-and-trade schemes without price control such as the EU ETS (see above and Dorsch et al., (forthcoming). More broadly, this can also be addressed through the formation of clubs whose members are willing to incur costs to impose sanctions on others who do not cooperate (Nordhaus 2015; N. Keohane, Petsonk, and Hanafi 2015; Burtraw et al. 2015). Thus in general, free riding can be remedied by expanding the coalition of nations or states enacting meaningful carbon reduction policies through policies aimed at cooperation or at least coordination.

An alternative solution is to take advantage of political and economic interconnection across jurisdictions to facilitate the diffusion of more stringent carbon policies (Bernstein and Cashore 2012)—what might be called "reverse leakage." One way of doing this is to proliferate policies among subsidiary jurisdictions (states) to create a patchwork of regulations that hamper commerce and may trigger a policy response at a higher level of jurisdiction (the EU or United States) to rationalize economic interests. Another way is to make use of markets to diffuse clean technologies. For instance, the same interconnection of the electricity grid that allows for electricity produced from coal-fired power plants to enter into California (producing leakage from California's aggressive decarbonization efforts) also means that the state's policies promoting renewable energy have supported wind and solar power projects in neighboring jurisdictions seeking to serve the California market. Similarly, it is often said that Germany made substantial contribution to "buying down" the learning curve of solar PV. Over time, such diffusion of technologies may have a range of impacts in recipient jurisdictions, including changing the underlying political dynamics to increase support for climate policy.

Observations: Germany's main activities to counteract free riding relate to its broader orientation of foreign policy; the UNFCCC, Group of Seven (G7), and Group of Twenty (G20); and particularly, the European Union (EU). Germany, operating in the context of the EU, was one of the driving forces in developing the UNFCCC regime and

TABLE 4. SEQUENCING OPTIONS FOR FREE RIDING

Specific barrier	Sequencing options
Free riding and lack of international institutions	Develop an international climate regime Build climate coalitions: • Link policies with similar-minded jurisdictions • Use of transfers to provide compensation for jurisdictions reluctant to join
Change choices and preferences of other jurisdictions	Take advantage of "reverse leakage" • Leverage economic interconnections (e.g., markets) to diffuse clean technologies • Leverage political interconnections (e.g., federal system) to diffuse policies, standards, and norms

adoption of the Kyoto Protocol in 1997; this was essential for enabling the setup in 2005 of the EU ETS, which faced significant obstacles (Wettestad 2005). A branching point year was certainly 2007, when Germany advanced climate policy internationally on two levels: First, it invested political capital into including the 2°C target in the G7 conclusions during its EU presidency in 2007, which paved the way for later recognition of the 2°C target in the UNFCCC context. Second, that same year, the European Commission proposed a 2020 climate and energy framework with an EU-wide target of 20 percent emissions reduction relative to 1990 and 20 percent renewables in total energy consumption. This proposal was readily adopted by the European head of states (European Council), and empirical research suggests that the effective leadership of Germany was a central driver (Boasson and Wettestad 2013). Also, transfer rules embodied in the EU ETS sharing of auctioning rights among member states were an important element in ensuring feasibility (Dorsch et al., forthcoming). Progress on the international level was arguably an essential factor in enabling the adoption of the 2011 Energiewende package, with its very ambitious 2050 GHG reduction and renewable extension targets, and thus this might be interpreted as an instance of sequencing. It also set the context for current efforts of ratcheting up the level of ambition of the EU ETS by increasing the linear annual reduction of its cap from 1.74 percent to 2.2 percent.

California is also engaged in multiple channels to address concerns over free riding. First, California uses the political channels of the US federal system and has pursued an iterative process, interacting with other jurisdictions and the national government repeatedly, most often with respect to conventional air pollutant regulation (Carlson 2009). California has a unique ability under the federal Clean Air Act to request a waiver of federal mobile source emissions standards and issue its own stricter standards, and if approved, others states have the ability to adopt California's stricter standard. This process has played out repeatedly, resulting in an iterative ratcheting up of federal standards.[8] The foundation of recent US climate policy thus had its roots in California before "ratcheting out" to affect other state, and ultimately national, policy. Second, California presently engages with other states and Canadian provinces as part of the Western Climate Initiative, which led to the linking of the California and Quebec trading programs; linking with Ontario is expected in 2018. Third, California also leverages markets to diffuse clean technology or prevent the use of dirty technology, e.g. SB 1368 precludes utilities from entering long-term contracts to buy coal-based electricity from other states.[9] Another effect, though possibly a less intentional one, is the diffusion of environmental protection standards to other states and jurisdictions, known as the "California effect" (Vogel 1997).

The broader question for sequencing is how to combine unilateral actions and multilateral cooperation elements over time and under changing conditions.

4. Discussion and Conclusions

The turn to implementation after Paris has placed a focus on incremental nationally determined policies to achieve the agreement's aspirational goals. Economic thought is often disparaging of the bottom-up policy mixes that have emerged so far and upholds that a dynamically cost-effective pathway with increasing stringency and a gradually increasing carbon price is the first-best policy. A main value of the economic approach is clarity, abstracting away from typically complex constraints that probably are used frequently as excuses to justify a status quo. But it provides little guidance about how to implement such a pathway amid complex existing policy barriers. The critical assumptions of the economic approach are that policymakers can indeed be persuaded of the necessity of the first-best pathway and that overcoming barriers is within their powers.

The approach we take shares the first critical assumption that desirable policy outcomes can be identified and policymakers can be persuaded, but we question the assumption that overcoming constraints is directly within their powers. Instead, we assert that some of the constraints—which we conceptualize as barriers to stringency in this paper—may be irremovable in the short run, and that in consequence, the best feasible short-term policy can only be a second-best one, which according to theory can substantially differ from the first-best policy. We look to California and Germany for evidence that incremental second-best policy actions may tend toward or be essential to overcoming barriers to more stringent policy. Quoting Marcus Aurelius, a core principle underlying this approach is that "the impediment to action advances action. What stands in the way becomes the way." The main value of the approach we describe is practicality: policymakers can be provided with more targeted advice that better addresses their actual decision problem that is constrained by barriers to higher stringency. Moreover, by removing barriers over time, an unconstrained first-best situation might eventually be achieved. A critical assumption of this approach is that policies can evolve

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[8] In a related issue, under the Clean Air Act, citizens and states have the unusual ability to sue the federal government. This was the mechanism that enabled several states, including California, to sue the US Environmental Protection Agency to issue stricter national motor vehicle standards aimed at GHG emissions. This lawsuit led to the seminal US Supreme Court decision in 2007 (*Massachusetts v. EPA*) affirming the agency's authority to regulate greenhouse gases under the Clean Air Act.

[9] Source: http://www.energy.ca.gov/renewables/tracking_progress/documents/current_expected_energy_from_coal.pdf

toward the first best and not get locked into inferior solutions when overcoming existing barriers or create new barriers that may move policy farther away from it.

The theory of change that we describe is policy sequencing, a dynamic and incremental process. Taking account of the timing and evolution of policies allows for processes—notably, the overcoming of barriers through a sequence of policies—that can move initially inferior second-best pathways closer to the first-best pathway. As a theory of change, this makes sense only if its main claim can be evaluated. The direction of policy needs to be in some sense headed toward better design, and to measure this, we look for increasing attributes of first-best policy outcomes, primarily cost-effectiveness or rigor, or designs that successfully overcome barriers to those outcomes. The first-best pathway serves as an endpoint—a benchmark to be achieved in the future—which in the sequencing framework serves for both assessing past and designing future policies over time.

To operationalize this framework requires a method for the evaluation of policy change over time using suitable sequencing indicators. Typical climate policy indicators such as emissions reductions or targets so far are imperfect proxies; for example, ample evidence shows that emissions can decline as a result of external forces such as business cycles, giving the appearance of progress even without structural change. Similarly, typical policy indicators such as price levels seem to be imperfect. In the EU ETS, for example, does the very low price on carbon imply that no progress has been made over the past decade? Instead of measuring progress solely by the short-term emissions quantity or price outcome, we might look to the architecture of emerging institutions to see if they provide a foundation for greater cost-effectiveness and greater stringency over time. Also, the relative economic resources of competing interest groups (measured, for example, in market shares of different technologies) may be a relevant indicator. Based on a better understanding of barriers to policy, sequencing could be used to devise new indicators and implicit stages to more rigorously and carefully answer such questions. This is where we see one important avenue for further research.

Sequencing seems to be a particularly useful framework because it focuses on the capacity of a policy to allow for ratcheting up, implying the anticipation of future developments. We have identified apparent relationships between barriers to policy; advances that have been made in two leading jurisdictions, California and Germany; and specific aspects of what appear to be sequential and incremental policy in those jurisdictions. But such a posteriori explanations of observed behavior require a structured analysis. Hence we have offered a framework for analysis, not claiming to have been comprehensive in identifying barriers and policy sequences to relax them. Further comparative research will be required. For now, we use this empirical comparison to formulate hypotheses to motivate further work to advance theory development. Such a theory could inform the design of policies specifically from a sequencing perspective.

Our first set of hypotheses is related to the possibility that overcoming existing barriers may lead to new barriers that might be called *bad lock-ins*. For example, vintage differentiated regulation that excludes older sources from stringent emissions standards imposed on new sources is a standard practice in second-best policymaking, but scholarship indicates that these exemptions are hard to reverse and may lock in deleterious environmental outcomes. Furthermore, there is evidence that sustaining the support for policy over time requires catalyzing new supporting coalitions, in particular if the original coalition for its introduction fades from view. This is a characteristic of technology support policies: they create new coalitions with vested economic interests. However, anecdotal evidence suggests that the renewable coalition in Germany is a significant force in opposing a move to more stringent carbon pricing that would replace renewable support policies because this endangers its business model. Similarly, in North America, it is argued that the rapid expansion of natural gas–fired generation, which has contributed to emissions reductions in the last decade, could lead to a lock-in under carbon pricing that creates near-term incentives for even greater natural gas infrastructure, which may result in a new constituency that is opposed to further efforts at deep decarbonization. Promising research would be to better understand, on both a case-specific and more general level, whether and under what conditions winning coalitions for one stage indeed pose a barrier for sequencing options, and how this particular type of barrier could be overcome.

Our second set of hypotheses relates to how to gradually *advance existing policies in the direction of the first best*. Although they are not usually thought of as first best, we observe existing technology support policies to be common in California and Germany, and the interaction of these policies with an emissions cap in both settings functions to drive down the carbon price. In fact, we observe a tendency in cap-and-trade schemes worldwide for prices to decline or remain low rather than rise, and to remain low compared with first-best energy-economic modeling of ambitious GHG reduction goals. However, a sharp rise in carbon prices would face strong political opposition, possibly jeopardizing the ratcheting up of the policy. If successful policy will continue to be sequential and incremental, then rejection of technology support policies and insistence on an exclusively ideal first-best approach might distract from what can be achieved in the near term. Instead, one might focus on policy attributes that provide architecture for further progress. For example, the minimum carbon price, which is already implemented in California—and now is increasingly proposed as a remedy to the EU ETS price crisis—appears to provide an obvious reconciliation between an emissions cap and technology policies.

Moreover, *some attributes of first-best policies might themselves provide a barrier to policy*, at least transitionally. For example, an advantage of regulatory standards seems to be that costs are hidden; this runs counter to transparency, which might be described as a positive attribute of carbon pricing. Does this imply that certain attributes have to be given up (partially) for the sake of achieving others, at least initially? Are regulatory standards perhaps *more* transparent to the general public than the vagaries of market forces? Within the current policy mixes in the case studies we have considered, a minimum carbon price appears to be an essential complement to technology policies if climate policy is to be viewed as a sequential process. On a more general level, this raises the questions, to what extent and in what form is carbon pricing part of the solution to overcoming stringency barriers? Framing these questions within a policy sequencing framework suggests a new avenue of research.

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