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Overcoming the tragedy of super wicked problems: constraining our future selves to ameliorate global climate change

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Abstract Most policy-relevant work on climate change in the social sciences either analyzes costs and benefits of particular policy options against important but often narrow sets of objectives or attempts to explain past successes or failures. We argue that an "applied forward reasoning" approach is better suited for social scientists seeking to address climate change, which we characterize as a "super wicked" problem comprising four key features: time is running out; those who cause the problem also seek to provide a solution; the central authority needed to address it is weak or non-existent; and, partly as a result, policy responses discount the future irrationally. These four features combine to create a policy-making "tragedy" where traditional analytical techniques are ill equipped to identify solutions, even when it is well recognized that actions must take place soon to avoid catastrophic future impacts. To overcome this tragedy, greater attention must be given to the generation of path-dependent policy interventions that can "constrain our future collective selves." Three diagnostic questions result that orient policy analysis toward understanding how to trigger *sticky* interventions that, through progressive incremental trajectories, *entrench* support over time while *expanding* the populations they cover. Drawing especially from the literature on path dependency, but inverting it to

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develop policy responses going forward, we illustrate the plausibility of our framework for identifying new areas of research and new ways to think about policy interventions to address super wicked problems.

Keywords Wicked problems · Super wicked problems · Climate change · Policy analysis · Environmental governance · Path dependency

Introduction

Climate change science is well developed, relatively coherent in terms of theory and method and capable of measuring, analyzing, and assessing what we do and do not know about the environmental consequences of climate change. By comparison, social scientific research on climate change is more recent, far less coherent, and lacks consensus on either epistemological or substantive grounds. The most policy-relevant work tends toward two types. The first analyzes the costs and benefits of particular policy options against important but often narrow sets of objectives in which the future is discounted. The second attempts to explain past successes or failures. While this research has value, we argue that an "applied forward reasoning" orientation and a focus on identifying triggers for path-dependent processes that unfold over time is required to address a new class of "super wicked" problems, exemplified by climate change.

We elaborate on this argument by addressing three inter-related questions: How should the policy challenges stemming from climate change be conceptualized? Based on that understanding, what are the appropriate analytical tools to address such problems? Finally, what do those tools tell us about what types of policies are likely to succeed or fail to reduce greenhouse gas emissions?

To address the first question, we expand Rittel and Webber's (1973) conceptualization of "wicked problems" that lack simplistic or straightforward planning responses, by introducing the term "super wicked" to characterize a new class of global environmental problems. Super wicked problems comprise four key features: time is running out; those who cause the problem also seek to provide a solution; the central authority needed to address them is weak or non-existent; and irrational discounting occurs that pushes responses into the future. Together these features create a tragedy because our governance institutions, and the policies they generate (or fail to generate), largely respond to short-term time horizons even when the catastrophic implications of doing so are far greater than any real or perceived benefits of inaction. How do we reorient our institutions and policies to respond to our long-term collective interests so that this tragedy can be overcome?

To address this tragedy—the focus of our second and third questions—we argue that policy analysis for super wicked problems can benefit from greater attention to understanding how "path-dependent" policy interventions might be generated to affect future policy requirements and, ultimately, behavior. Since climate change is, in part, driven by policies and technologies that created a path-dependent reliance on "high carbon" fossil fuels (Unruh 2000), we propose nurturing countervailing policies that might trigger path-dependent "low carbon" trajectories. While most scholars of path dependency focus on its negative consequences for efficiency and/or social policies, our approach turns this literature on its head by looking forward in time rather than backwards to elucidate how generating path dependencies might foster desired policy outcomes in the future. This strategy leads us to explore the interaction of policies that may be fragile at first and/or apply to only a small group, but which may trigger path-dependent processes that unfold

over time. It focuses attention on how interventions might not only focus on achieving immediate "stickiness" but also how they gain *durability, expand* the populations they cover, and *change* behaviors through largely unexplored *progressive incremental* forces whereby a number of small policy changes can have significant transformative effects if they trigger path-dependent processes.

We argue that this policy approach requires a new epistemological orientation—applied forward reasoning—to understand both the policy choices that "constrain our future selves" and to generate new policy tools that set in motion these choices, consistent with long-term collective and individual interests. The challenge, we argue, is not a lack of interest to address super wicked problems. Rather, it is to counteract the tendency of our political institutions, as reinforced by our individual tendencies as consumers and voters, to make decisions that give greater weight to immediate interests and to delay required behavioral changes, even when doing so is clearly contrary to our long-term interests. An applied forward reasoning approach facilitates the identification of causal logics of path-dependent processes applicable to a range of potential interventions that can progressively ratchet up policy requirements. While our approach is consistent with some insights from psychological and behavioral sciences research on how to counteract irrational *individual* tendencies in areas such as smoking or investment decisions (Thaler and Sunstein 2008), it goes beyond such work to draw out underexplored insights from research on the policy process on how to bind our *collective* selves (Elster 2002).

Hence, our approach has explicit prescriptive implications: it identifies new ways to develop and assess policy interventions based on whether they contain "plausible logics" for triggering one or more path-dependent process reviewed below. Specifically, it guides policy analysts to assess what policy access points and levels or "orders" of policy to target. Most importantly, it suggests they should focus more attention on coalition building on the one hand, and norms and values on the other hand, for unleashing path-dependent trajectories capable of ameliorating super wicked problems.

Interest in applying the role of path dependency for developing long-term and expanding interventions capable of addressing climate change as a "wicked" or "super wicked" problem has gained increasing attention (Webster 2008; Maréchal and Lazaric 2010; Maréchal 2010; Lazarus 2009; Frame and Brown 2008) since we first introduced and defined the term "super wicked" and turned to the path dependency literature for potential solutions (Levin et al. 2007). While these papers reinforce our characterization of climate change policy, our analytical orientation leads us to different policy guidance. Unlike Webster (2008) and Lazarus (2009), we argue that one-shot "big bang" policies for super wicked problems, which require behavioral change by all relevant populations immediately, either fail to garner adequate support or, in those rare cases where such policies are adopted, are likely to produce societal "shocks" that hamper implementation and compliance, derailing a policy no matter how well designed. Even if such a policy survives, rarely do decision makers assess how the policy might be designed to ratchet up over time to become more ambitious. Hence, our analytical framework is highly relevant for understanding how these efforts can remain resilient and how their trajectories and transformative potential on behavior can be reinforced.

We proceed as follows. First, we identify climate change as a super wicked problem and three diagnostic questions to guide policy deliberations that result. Second, we introduce our applied forward reasoning approach and defend its epistemological orientation. Third, we develop an analytical framework sensitive to policy change processes in general and path-dependent logics in particular. Fourth, to show the plausibility and utility of our approach, we introduce a protocol policy makers will want to follow when considering how best to intervene to both trigger and nurture one or more path-dependent processes.

The tragedy of global climate change as a super wicked problem

There is widespread agreement among the global scientific community that it is "very likely"[1] that human activities are responsible for increases in carbon dioxide and other greenhouse gases and that their buildup explains documented average temperature increases (Intergovernmental Panel on Climate Change 2007). The rate of increase of global carbon dioxide emissions is, even despite the post-2008 global economic downturn, accelerating (IEA 2011). If greenhouse gas emissions do not decline drastically, ecosystems and human communities face a high risk of significant and widespread stress (Intergovernmental Panel on Climate Change 2007). While there is some uncertainty about the distribution of future impacts across the globe, decision makers generally agree that to reduce such risks, the rise in global average temperatures should be limited to below 2 °C above pre-industrial levels.[2] The Cancun Agreements, the main political outcome of the Conference of the Parties to the UN Framework Convention on Climate Change in December 2010, went even further, recognizing that scientific evidence may require keeping increases to 1.5 °C above pre-industrial temperatures (UNFCCC 2011).[3] Equally telling, however, post-Kyoto global climate negotiations have so far not produced any legally binding commitments to achieve such reductions. Despite 20 years of international and domestic efforts, greenhouse gas emissions are accelerating, and the development of legally binding targets and practices that result in the on-the-ground behavioral changes necessary to reverse that trend remains elusive. And while the Durban climate negotiations in December 2011 resulted in a roadmap to develop a legal framework over the coming years, parties may not ratify any future protocol, instrument, or agreed outcome with legal force until 2020, which is beyond the date by which scientists suggest global emissions must peak (UNEP 2011).

Rittel and Webber's (1973) article in this journal was one of the first to highlight the need for policy makers to carefully develop decision tools based on the problems they faced. They identified the term "wicked" to capture problems characterized by ten features, including those that had "no stopping rule" (they lack a discrete solution or end point at which one can say the problem is solved), that posed "no immediate test" of a potential solution, "no opportunity to learn by trial and error," and little opportunity for a planner to be "wrong." Their essay challenged then commonly held "rational" policy analysis techniques including neo-classical cost-benefit analysis, "satisficing" models (Simon 1957a), and even systematic "policy science" analytics (Lasswell 1956). Critics at the time argued these modes of analysis promoted planning approaches that contributed to, rather than solved, complex problems (Tribe 1972; Sen 1977).

While Rittel and Webber usefully highlight features of problems that decision makers ought to consider when determining which decision tool to apply, wicked problems arguably describe *most* policy problems. We identify four features unique to "super wicked problems," human-induced climate change being a prototypical example, which reinforce and direct our attention to the need for a new epistemological and theoretical orientation to policy and planning.

[1] "Very likely" constitutes more than 90 % probability.

[2] Some decision makers and scientists have argued that the number should be actually lower, but few argue it is higher.

[3] See http://unfccc.int/files/meetings/cop_16/application/pdf/cop16_lca.pdf.

Time is running out

The notion that *time is running out* separates many environmental concerns from social challenges. In the latter case, much of what is considered appropriate policy is mediated by the political system. Stakeholders with various interests interact and attempt to influence each others' policy preferences. The political system then responds, or fails to respond, with some kind of policy intervention. Losing coalitions tend to regroup, build more support for their ideas, and then attempt once again to influence the policy agenda. For example, the failed 1993 effort to promote universal health care in the United States resurfaced under the Obama administration, with different results. Those wishing to address super wicked problems such as climate change, however, do not have the luxury of "coming back" to the political system for a retry, exacerbating the "one shot" problem noted by Rittel and Weber. The time dimension means the problem will, at some point, be too acute, have had too much impact, or be too late to stop or reverse. Put another way, while the political system may mediate interest group interactions regarding climate change policy in similar ways as it does regarding universal health care, the natural environment has its own response that stakeholders and governments cannot wish away. Indeed, the powerful image of "compromise" that shapes most public policy processes does not fit. Human beings can, of course, control their behavior to alter their impacts, but they cannot control the response of the natural system once a decision is made. The natural environment is the final arbiter of whether policy responses are appropriate.

Climate change is arguably the most illustrative case of time running out. Significant impacts *will* occur; with each passing year, they become more *acute;* and if we do not act soon, the risk of harm to human communities and ecosystems, as well as non-linear change and catastrophic events, increases. Six years back, some estimated that we had roughly 10 years to peak emissions in order to avert dangerous anthropogenic change (Hansen 2006). Hence, and unlike health care reform in the United States, humanity may only have a small window in time to move from its carbon-intensive trajectory to avoid significant harm.

Those seeking to end the problem are also causing it

Since those individuals who participate in coalitions that advocate emissions abatement also cause the problem, contestation over climate change differs from, say, political contestation over health care, access to abortion services, or a military intervention. Every concerned person trying to reduce climate change has contributed to climate change. Everyday activities, including proportionally higher per capita emissions in wealthier countries, are major culprits. Unlike other environmental problems with discrete antagonists and protagonists, human-induced climate change results from individual and collective activities at multiple scales, as well as marketplace activities. While individuals can choose to switch to non-fossil fuel-generated power, buy efficient vehicles or lower consumption of carbon-intensive goods, many of our daily activities will still result in greenhouse gas emissions. In the United States, one of the world's largest per capita emitters, for example, residential homes generate roughly 17 % of total carbon dioxide emissions and passenger vehicles emit 20 % (Environmental Protection Agency 2007; Pegg 2002).

No central authority

Decision makers within public authorities do not control all the choices required to alleviate pressures on the climate. This problem adds to the general problem of cooperation

under anarchy that characterizes any global collective action problem. The lack of centralized governance has repercussions at multiple levels in the case of climate change since responses require coordination not just among states, themselves in a variety of different circumstances, but also across different economic sectors and policy subsystems at multiple political levels. Even if a strong global agreement on ambitious emission reduction targets could be achieved, mechanisms and programs are likely to operate simultaneously at multiple scales wherever sufficient authority can be generated. One example of this trend is the proliferation of carbon markets. Though some coordination is occurring, such as the EU-wide system and sub-regional systems set up by US states and Canadian provinces (Betsill and Hoffmann 2009), fragmentation and diffuse authority characterizes the overall global policy regime.

Policies discount the future irrationally

Partly as a result of the above three features, super wicked problems generate a situation in which the public and decision makers, even in the face of overwhelming evidence of the risks of significant or even catastrophic impacts from inaction, make decisions that disregard this information and reflect very short time horizons. It is this very feature that has frustrated so many climate policy advocates. This phenomenon is analogous to smokers who, while they know the high probability of significant health problems and even death, make a decision to smoke based on immediate gratification. This characteristic is especially pernicious because although it is known that negative effects will occur (such as respiration challenges for the smoker) and that there is a high risk of catastrophic events (such as a heart attack or lung cancer), the precise consequences are never certain for any one individual.

Behavioral economists have long focused on such "time-inconsistent" preferences, in which individuals apply a declining social discount rate to the long-term future in a manner that gives greater weight to consumption now than what the economic tool of a constant discount rate suggests is "rational" (Strotz 1955; Elster 2000; Rabin 1998, 39–40; Karp 2005, 263; Ascher 2009). Although this phenomenon means individuals are less short-sighted about future trade-offs (e.g., the trade-off between consuming a cigarette a year from now versus a year plus a day from now is much less significant than the trade-off between consuming a cigarette now versus tomorrow), the key challenge that militates against behavior change is the size of the short-term discount rate, which makes individuals heavily weight consumption now. Hence, to become more foresighted, behavioral economists argue, individuals must "lock-in" long-term preferences so that, as the future nears, they cannot revert to their short-term calculus. This is why a host of web sites now exist where individuals can draw on social sanctioning by committing to desired behavior changes, such as weight loss, exercise, or quitting smoking. A reformed smoker, for instance, can pay someone on Monday to hide her cigarettes on Thursday, when she knows that severe cravings will make her unable to trust her future self. The reformed smoker on Monday makes a rational decision, recognizing she is subject to time-inconsistent preferences, to fight Thursday's cravings.

While scholars have explored individual tactics to overcome this behavioral problem, super wicked problems require that we also focus on institutions and the policy-making process that affect our ability to address this problem at the collective level. Super wicked problems are confounded by the tendency of our political institutions to make decisions that give greater weight to society's immediate policy interests and to delay required behavioral changes, often by the use of ostensible commitments to reduce greenhouse gas emissions that have little or no immediate effect. These tendencies to punt policy choices

are exacerbated by near-term costs and the belief by some that these disincentives will diminish in the future (e.g., via the availability of less expensive technology or increased costs of inaction). Yet, as the future approaches—when we planned to act on climate change—the salience of the short-term costs returns, presenting a vicious cycle. Hence, this circumstance demands collectively rational responses to "constrain our future selves" (Ainslie 2001).

A tragedy

These four features present challenges for traditional policy analysis techniques that tend to take preferences as fixed and focus on short-term strategic "self-interest." These assumptions present a truncated view of human behavior that not only cannot explain the "tragedy" of super wicked problems but also limit analyses of possible policy responses to them. Even though we collectively recognize the need to act now to avoid future catastrophic impacts, the immediate implications of required behavioral changes overwhelm the ability of the political and policy systems at multiple levels to respond. Hence, democratic politics and institutional design are not only about mediating competing and relatively short-term focused interests but are also about battles we are waging against ourselves. To overcome the tragedy of super wicked problems, we need to nurture a policy process in which our long-term interests gain sway over our short-term interests.

When exploring the "tragedy of the commons," Garrett Hardin and Elinor Ostrom both discuss resource depletion driven by individuals acting in their own immediate interests and focus on interventions and institutional arrangements that control and/or exclude access to avoid resource depletion within a particular local commons (Hardin 1968; Ostrom 1990). We, too, focus on interventions and institutional arrangements to overcome a governance tragedy—in our case, the one inherent to super wicked problems. However, unlike them, we eschew thinking about the problem in terms of individual rational choices and depart from behavioral economics work on time-inconsistent preferences because both are oriented toward understanding whether individuals act consistently with a rational "discount rate," and accordingly, whether it is "rational" to address global climate change (Barkin 2006; Ackerman and Heinzerling 2004; Sinden et al. 2009). We focus instead on collective rationality that begins, and ends, with addressing the problem of climate change as identified by scientists. Almost no country or intergovernmental agreement has developed policies consistent with this scientific evidence, and it is this fact we treat as irrational.[4]

Hence, we explore how policies built on the causal logics of path-dependent processes can help constrain future behavior to achieve desirable longer-term social benefits. Just as Hardin and Ostrom argued a solution to resource depletion lay in developing new institutional arrangements to overcome the human tendency to overexploit, we argue that super wicked problems require the adoption of new policy analysis techniques that are consistent with, rather than ignore, the key features of this class of problems. Accordingly, three diagnostic questions (DQ) emerge (Table 1) that policy makers will need to answer when deliberating how to intervene to address super wicked problems:

DQ1: What can be done to create *stickiness* making reversibility immediately difficult?
DQ2: What can be done to *entrench* support over time?
DQ3: What can be done to *expand* the population that supports the policy?

[4] In this sense debates on "rational" discount rates may contribute to the current "irrational" responses in domestic and international policy (see Kysar (2010) for a complementary argument).

Table 1 Diagnostic questions to guide intervening to ameliorate super wicked problems

Plausible logic	Existence	Implication
DQ1: That immediate stickiness will occur	Useful	Buys time, but not a prerequisite as long as increasing support over time kicks in quite quickly
DQ2: For initial population increasing support over time	Prerequisite	This must occur for path dependency to address super wicked problems
DQ3: For expansion of population	Prerequisite	This must occur for path dependency to address super wicked problems

The first two questions direct policy makers to trigger processes that create benefits for groups who change their behavior as a result of the policy and hence offset status quo bias. Such processes directly address the irrational discounting of super wicked problems by political systems and policy processes wherein previous commitments for change are often annulled as we near their required impacts. The third question directly addresses how the challenge of no central authority might be overcome through progressive incremental forces. While it does not follow that answering these questions *will* always result in the amelioration of super wicked problems, our point is that asking them may uncover innovative solutions worthy of consideration.

Applied forward reasoning: an alternative epistemology

Conventional policy analysis tools are poorly situated to help find policies to bind "our future collective selves." These approaches tend to compare policy instruments against a single goal, such as efficiency, and apply some variation of cost-benefit policy analysis (Arrow et al. 1996) or multi-goal analysis in which impacts are compared through a type of weighting process (Weimer and Vining 2004). In an effort to provide clarity, these approaches assume a relatively linear and predictable world in which decisions about whether non-efficiency goals are attainable result from, rather than precede, the comparative exercises (Tribe 1972; Kysar 2010).

For super wicked problems, however, the well-known difficulties of probabilistic prediction in the social sciences are magnified (Bernstein et al. 2000). Like many other policy challenges, super wicked problems occur in open, non-linear systems, where human beings may also interact in reflective and unpredictable ways to change their environment. In addition, the nature of these problems makes the utility of the usual backward looking method of prediction—really post-diction—typical of deductive-nomothetic theory problematic. A research strategy with the aim of finding general explanations is simply ill-advised for problems with super wicked characteristics. A more appropriate research goal is to identify possible policy interventions and reason forward to how the problem and interventions might unfold over time. As Patomäki explains, forward looking policy analysis ought to be "…interested in other possible and likely futures, and in determining the ways in which our actions and the actions of others contribute—sometimes via unintended effects and consequences—to making some of them real" (Patomäki 2006, 12).

Developing such an approach poses a serious dilemma for social science theory in two respects. First, mainstream social science has been built on examining the past and

focusing on measurable, replicable, and large-N data sets with which to undertake regressions and other statistical techniques that tend to "black box" historical causal processes (Hall 2003). The limits of this approach have been addressed most directly by Bernstein and colleagues, who recommend an epistemology drawn from evolutionary biology rather than Newtonian physics. They suggest the method of "forward reasoning" scenario building that recognizes contingency, the need to consider multiple alternative futures, and the development of plausible plot lines based on contingent causal mechanisms and critical uncertainties. Second, most social scientists working to uncover or develop general explanations are hesitant to apply their efforts to intervene in specific world problems. This tension between explaining ("analysis of") and prescribing ("analysis for") has long characterized comparative public policy and policy sciences literature, dating at least from the Simon (1957b) and Lindblom (1959) debates about the utility of the rational comprehensive "satisficing" model versus "incremental" approaches to policy development. Since that time, many disciplines have gone in the opposite direction from the multi-disciplinary and holistic approach envisioned by Lasswell, Brewer, and other early policy scientists (Howlett and Ramesh 1995; Pal 2000). One pathway focuses largely on theory building to explain past events, and another focuses on comparing and contrasting policy interventions according to select criteria, predicting their effects, and then choosing a "single-shot" intervention to address a problem (Weimer and Vining 2004).

Bernstein et al. (2000, 53) argue that rather than engage in prediction (that is biased toward single-shot analysis), a more appropriate goal of policy-relevant social science is the "identification and connection of chains of contingencies that could shape the future." Proponents of scenario building through forward reasoning argue that the price of mainstream policy analysis techniques that ignore contingency and reduce complex historical processes to narrow cost-benefit analysis and mathematical models is to favor precision over accuracy—something that must be avoided to address the urgent need to change global behaviors affecting super wicked problems.

For this purpose, we move beyond Bernstein and colleagues' explanatory goals to adopt an applied approach that explicitly links causal analysis to prescriptive solutions. While recognizing the risks that any intervention may lead to unintended consequences, the purpose of an "applied forward reasoning" approach is to identify ways in which interventions might create particular policy pathways that move toward preferred outcomes. Our approach is complementary to, but distinct from, other scenario-building efforts, which attempt to identify logics and take into account contingencies that could lead to different futures.[5] Instead, we focus specifically on policy logics that may trigger and nurture path-dependent processes that lead to transformative change over time.

Toward an analytic framework for tackling the tragedy of super wicked problems

Our framework, based on applied forward reasoning, addresses two questions: what path-dependent causal processes respond to the three diagnostic questions, and what actions might trigger them?

[5] Most concretely, our effort builds from the *Policy Reform* scenario advanced by Raskin et al. (1998), which begins to offer advice on the character of policy interventions—such as the need for flexibility and adaptation—necessary to accomplish a set of broad environmental and social development goals.

Policy development

The literature on policy development yields two insights for identifying candidate path-dependent processes. First, change and stability in policy choices must be tracked over time (Clemens and Cook 1999; Mayhew 2002). Baumgartner and Jones (1993) have asserted that seemingly stable policies are often "punctuated," moving them to a new equilibrium. The implication is that policy analysts should focus on better understanding when "windows" or "triggers" cause such punctuations. Cashore and Howlett (2007), drawing on Durrant and Diehl (1989), help identify the policy implications of different approaches to trying to create such punctuations that are relevant to super wicked problems. They conceptualized four types of policy development that differentiate change that is progressive and transformative from change that does not reflect a new punctuated equilibrium. Two types of change are in equilibrium: "faux paradigmatic" in which what appears to be a significant change only ends up being reversed (often following the election of a new government); and "classic incremental" in which small changes oscillate creating limited behavioral change and/or impact on the policy problem. Two other processes of policy development head toward a *new* equilibrium: the "classic paradigmatic" in which a single-shot big change occurs that is not reversed; and the much less studied "progressive incrementalism," where policy development is characterized by steps, which can accumulate over days, weeks, months, years, and decades to produce significant results (Table 2).

These distinctions are important to avoid misdiagnosing those short-term, single-shot large changes as transformative that are more likely "faux paradigmatic" (such as when major initiatives of one political party are reversed following the election of the opposition party). They also underscore the potential of misdiagnosing progressive incremental processes as single-shot paradigmatic. Often antecedent and unexplored progressive incremental forces that create, and lead to, well studied "tipping points" are not sufficiently recognized.[6] This neglect justifies our focus on these potential progressive incremental triggers, and drawing on these lessons, to apply them forward. Finally, the time dimension of progressive incrementalism requires careful attention: actors who attempt to trigger such change must assess whether there is a plausible logic that an intervention, or set of interventions, is likely to unleash a path-dependent process that can change behavior *before* the time runs out to address the super wicked problem in question.

The second insight from the policy development literature is that different "levels" or "orders" of policy characterizing a policy regime—from abstract goals and broad instrument preferences to specific technical settings and calibrations—may change and remain stable according to different causal processes (Cashore and Howlett 2007). To better understand these processes, and to chart the course of policy change, analysts focusing on triggering policy solutions for super wicked problems must recognize and disentangle these different levels and the opportunities they provide. At each level, for instance, the role played by government officials may vary. Specific details of policy are often easier for bureaucrats to change than broad policy goals (Hall 1993). This is because government officials almost always have more discretion in fine-tuning (e.g., changing the speed limit from 60 to 55 miles an hour) than changing overarching goals (e.g., to reduce traffic deaths or auto emissions), which come from, and are reinforced by, engrained

[6] For a powerful illustration of the prevalence of these misdiagnoses, see Mayhew's (2002) review of US scholarship on electoral realignment, which he argues misses the gradual processes underlying perceived single, short policy punctuations. We are grateful to an anonymous reviewer for this point.

Table 2 Taxonomy of change and stability

	Change (from previous position)	
Directionality	Large	Small
Cumulative	Classic paradigmatic	Progressive Incremental
In equilibrium	Faux paradigmatic	Classic incremental

Source: Cashore and Howlett (2007) adapted from Durrant and Diehl (1989)

societal norms about what types of problems are "appropriate" for policy makers to address.

The implication of this literature for super wicked problems is that policy scientists and practitioners should reflect on the opportunities and possibilities of triggers of policy change at different levels. For instance, a choice between policy instruments (e.g., cap-and-trade versus carbon taxes), though it may involve intense political negotiations, still tends to be easier to change than more normatively engrained goals, such as ideas about whether economic concerns ought to trump climate change. Policy instruments, however, are often *harder* to change than the myriad decisions made within policy subsystems, legislative committees, or by government officials about the technical settings and calibrations of cap-and-trade or carbon tax policies in operation.[7] Hence, policy makers considering intervening to address super wicked problems must take stock of what appears to be different windows of opportunity not just across time, but within different levels or orders of a policy regime. These insights are a foundation for the path-dependent processes we consider in the next section. We argue that greater attention should be placed on what are often much easier to change lower order policy levels in order to assess whether there are opportunities for initiating policy change capable of unlocking progressive incremental trajectories that ratchet up over time to create more meaningful impacts.

[7] An illustration of these "easier to change" policy settings is the 2009 US Health Care reforms. A popular provision to allow children who attend college to stay on their parent's health care plan until age 26 was made within a representative committee, rather than through a Senate vote. Arguably a Senate vote would have been hard to achieve given the practice of filibustering which means 41 senators can trump the wishes of 59. This provision has arguably already had significant path dependent effects, creating an immediate constituency supporting its maintenance, reducing the likelihood it will be reversed.

Four path-dependent processes

Research on path dependency has identified four processes useful for answering all three diagnostic questions. Empirical work on these processes document how (often relatively small) policy changes may have immediate stickiness (directly addressing DQ1), and most importantly, trigger unfolding historical policy trajectories that both entrench (DQ2) and expand (DQ3) their effects and coverage over time.

The roots of this scholarship within the policy sciences can be traced back to curiosity about why certain policies, technologies, and institutions endure despite the presence of other seemingly more appropriate or logical alternatives. Much of this interest was sparked by David's seminal article that asked why the QWERTY typewriter endured despite the existence of a more efficient DVORAK alternative (David 1985). Policy focused social scientists, drawing on David's insights, unite around the idea that there exist "key actions at any given historical moment" (Griffin 1993) that set a system on a particular path. Some have invoked a "branching tree" metaphor[8] to capture how a given policy decision can affect the course of development for decades and even centuries (Ertman 1997, 320) as decision makers in the future are limited to certain options (nearby branches), dictated by far-removed historical events (the branch originally chosen). This leads to an analytic distinction between the initial triggers and the processes of entrenchment that allow a particular social, economic, and political practice to endure and have expanding effects over time (Beyer 2005; Page 2006; Thelen 2003; Mahoney 2000; Hacker 2002).

We are inspired by this work, but also, consistent with empirical studies, curious about the role of government officials and other relevant policy participants as events unfold in facilitating (or debilitating) these possibilities and contingencies. We focus on how early decisions can work to constrain our future selves but also recognize that—contrary to some path dependency scholarship—decisions taken later or that "kick in" later can either reinforce or detract from an existing path, in this case the "low emissions" pathways upon which amelioration of climate as a super wicked problem must focus ultimately.

For analytic clarity, we first discuss the relevance of each path dependence process to our three diagnostic questions in isolation to assist in identifying the causal processes through which interventions might work. We then review existing findings about the independent and interacting effects of these processes in shaping historical policy responses relevant to our three diagnostic questions (Table 3).

Lock-in

Lock-in occurs when a policy intervention contains a logic that gives it immediate durability; hence, it is directly relevant to DQ1. In the case of the QWERTY typewriter, lock-in was attributed to immediate large capital costs of building a QWERTY manufacturing facility (David 1985). Within political systems, lock-in can result from institutional rules of the game that render change difficult to initiate (Pierson 2004). Most countries have followed this logic by creating significant hurdles for constitutional reform such that if change occurs, it is immediately hard to reverse (Elster 2002). These constitutional provisions themselves contain "logics" about policy change and durability of which policy makers must be aware. For example, many argue that the US separation of powers that makes it so difficult to pass reforms also means it is difficult to change existing legislation

[8] Verba (1971) coined this metaphor, which has became pervasive in the literature, see for example, (Pierson 2004; Hacker 1998; Levi 1997).

Table 3 Relevant path-dependent processes for diagnostic questions

Diagnostic questions	Relevant path-dependent processes			
	Lock-in	Self-reinforcing	Increasing returns	Positive feedback
DQ1: Stickiness (irreversibility)	✔			
DQ2: Entrenched over time		✔	✔	✔
DQ3: Expanding population			✔	✔

(Weaver and Rockman 1993). Hence, once in place, US legislation can have longstanding effects in ways that do not apply to other forms of government characterized by unicameral majority rule. These features, in turn, have significant implications for resource and environmental management. For instance, small regulatory provisions in the Endangered Species Act (1973) mandating federal agencies to "maintain species viability" on federal lands resulted in changes to forest policy management in the US Pacific Northwest, but not until the 1990s (Cashore and Howlett 2007). Identification of "lock-in" points policy makers and scholars to consider the logics of policy change that exist within different institutional settings including how "windows of opportunity" open and close that might permit them to trigger path-dependent policy trajectories (Kingdon 1995).

Although immediate lock-in is a process policy makers must consider, attention to the next three processes reveals it is not a prerequisite, nor is it likely ever sufficient, for initiating path-dependent trajectories capable of addressing such problems.

Self-reinforcing: costs of reversing rise over time

A second causal process termed *self-reinforcing* concerns policy interventions in which the costs of reversal increase over time. Page's (2006) extensive review provides a range of historical examples where an initial action "[put] in place a set of forces or complementary institutions that encourage[d] that choice to be sustained" (Page 2006, 88). Understanding how to unleash self-reinforcing processes directly informs responses to DQ2, since such processes will lead to entrenchment over time.

Pierson (2004) identified up-front investments where costs of reversal to the investor rise over time as one such self-reinforcing trigger. Importantly, the causal path-dependent impact does not always have to involve financial investments alone. Take the QWERTY example, where an initial labor force learned and developed skills to type on a QWERTY typewriter. Once these skills were learned, the existing population was more likely to want to stay with QWERTY, even if less efficient, given the sunk investments in their acquired skills. Self-reinforcing could also involve—as the health care example below reveals—the generation of norms that define "appropriateness" (March and Olsen 1996) that, sometimes sparked by routinization, can reinforce actions originally undertaken for self-interested reasons (Suchman 1995).

Increasing returns: benefits increase over time

A third causal process and mirror image of self-reinforcing, *increasing returns*, captures the phenomenon where benefits for an intervention, once introduced, increase over time (Page 2006). This process addresses DQ2 by orienting analysis toward promoting interventions that will yield increasing benefits to an initially covered population that can be expected to lead to enhanced support, promoting entrenchment. Increasing returns are also

relevant to DQ3 since once an uncovered population becomes aware of benefits others are receiving it is likely to have an interest in seeking such coverage. In the case of the QWERTY keyboard example, as the market for machines that produce QWERTY keyboards grows, manufacturers gain increasing benefits, while, as long as the market keeps expanding, new companies also benefit by entering the market, a process which repeats itself until a new equilibrium is established (David 1985).

Recognition that tipping points often result from such increasing returns processes also helps avoid misdiagnosing these progressive incremental trajectories as "single-shot" paradigmatic change. Arthur's research on technological competition, for example, identified thresholds where enough individuals choose a technology that all actors, regardless of their initial preferences, switched to this technological option (Arthur 1989). Such dynamics build from progressive incremental support that, over time, can lead to significant changes in behavioral impacts, such as shifts in management styles and the adoption of new technologies (Bigelow 1982; Herbig 1991).

Positive feedback: expanding populations and reinforcing original support

A fourth causal process, *positive feedback*, is a prerequisite for addressing super wicked problems because it focuses policy makers on nurturing only those processes that expand support beyond the initial target populations (DQ3) in ways that *reinforce*, rather than *detract* from, the support of the initial target population (DQ2). That is, positive feedbacks occur when others who are not initially part of the target population make decisions to join, and by doing so, reinforce the choices of the original target populations (Page 2006).

Three implications for choosing appropriate instruments to address super wicked problems result. First, policy makers must avoid triggering policies where immediate beneficiaries have a vested interest in stopping expansion to other populations.[9] (To take an example from US health care policy, this would require assessment of whether efforts to promote universal health care might have been hindered by those seniors on Medicaid who feared that expanding their program to the entire US population risked reductions in their benefits, thus removing support from an initial population.) Second, policy makers must also be careful not to accidentally trigger "niche market" type processes that address DQ2 by increasing benefits to the original population but inadvertently make it harder or impossible to address DQ3 because incentives are created that only exist if others are prevented from benefiting or joining. Third, policy makers must avoid playing a game of "whack-a-mole" in which DQ3-focused interventions gain the support of new populations while inadvertently losing support of the initial target population (DQ2). Shifting rather than expanding is a particular concern when seeking support for an intervention beyond "niche status" in ways that maintain benefits for early supporters. If these benefits are *reduced*, then entrenchment (DQ2) is at risk. Such a result would render policy makers unable to address the super wicked problem since the fragmentation of authority and collective impacts requires that interventions cover an expanding population.

[9] This point highlights our separation from Ostrom's design principles to address resource depletion challenges, which has, as a central tenant, *limiting* access to specified populations and, often, subsets through resource allocation. It would be a tragic mistake to apply such design principles to super wicked problems which, by their very nature, must incorporate, rather than exclude, all populations.

Independent and intersecting effects of path dependency processes

These four processes are not abstract intellectual constructs: extensive empirical research has documented that they work independently but also interact to produce path-dependent policy trajectories within and across a range of countries and sub-national jurisdictions. Arguably no better documented example of the importance of path dependency exists than US health care. Numerous scholars have sought to understand why the United States sits alone among industrialized countries in failing to provide health care for all of its citizens even in the face of often widespread societal support. This rich body of research has established that critical junctures demarcated by what appear to be relatively minor changes in policy calibrations and settings in the US worked to cast long shadows over future policy development, with each stage, progressive incrementally, making it more difficult to achieve universal health care (Tuohy 1999; Maioni 1999; Marmor 2007; Hacker 2002). The key triggering mechanism was a decision in the 1930s to grant tax-exempt status to prepay hospital plans (e.g., what became Blue Cross) (Tuohy 1999; Maioni 1999). This created *lock-in* (*DQ1*) among a small subset of the US population because once granted, removing the policy would have required removing benefits that were immediately popular among recipients (Hacker 2002, 203). Over many years, the tax-exempt status initiated *self-reinforcing* (DQ2) mechanisms in which a community of employers, hospitals, and doctors learned how to operate within the complexities of administering the private system, making a move to a different system more difficult. Colleges and educational institutes, which trained generations of accountants and other service providers to operate within the private system (Hacker 2002, 205), triggered *increasing returns* to existing insurance providers with trained labor that reduced their own human resources costs (DQ2). *Positive feedbacks* were also simultaneously created as other institutions expanded their training to meet this demand, which, in turn, expanded employment of people who had a vested interest in maintaining the system (DQ3) and encouraged institutional reproduction.

Increasing returns went beyond those employed in the private insurance industry, however, and also occurred, most importantly for our analysis, though increasing coverage of private health care insurance as those employees covered by the plans began to see the beneficial impacts of providing health services (DQ2). Employees without health coverage who witnessed these increases sought coverage (DQ3) and their actions resulted in *positive feedbacks*, reinforcing the support of those already covered.[10] These trajectories worked to create larger and larger political coalitions promoting private health care over public insurance, resulting in enhanced entrenchment (DQ2) of the private system. Taken together, these path dependent processes intersected to create an "accidental logic" (Tuohy 1999) in which policy development entrenched the original private insurance choice (DQ2) and progressive incrementally expanded the population covered (DQ3). As Hacker documents, membership in Blue Cross plans rose from 600,000 in 1937 to around 6 million by 1940, and over 15 million in 1945 (Hacker 2002, 214).

Path-dependent policy choices can also affect technological trajectories—clearly a key consideration for decision makers trying to make sense of what types of low-carbon technological innovations to nurture. For example, Islas (1997) and Cowan (1990) found that shifts to one technology over another are often fostered by policy decisions that build

[10] Huber and Stephens (2001, p. 28–29) use a similar logic to discuss a policy ratcheting effect in welfare programs more generally.

momentum from what were initially operating as niche environments (Kemp et al. 2001) (DQ3). Cowan (1990) discovered, for instance, that the US Government's decision to support light water technology via military contracts influenced the long-term outcome of competition between heavy and light water nuclear technology. This decision created *lock-in* among contractors who incurred immediate financial benefits by supporting this path (DQ1). Internal learning and training within the US navel program about light water reactors likewise triggered *self-reinforcing* processes (DQ2), which then produced *increasing returns* as the US naval program gave preferential treatment to light water industries in its nuclear contracts (DQ2). In turn, these processes created conditions for *positive feedbacks* as the demand for civilian nuclear power turned to light water technology since it was now well advanced compared to other technologically late entrants (DQ3). This demand led to even more increasing returns for the light water option (DQ3). By the mid-1980s, over 80 % of installed nuclear capacity in the US came from light water reactors (Cowan 1990).

Playing it forward: intervening to ameliorate super wicked problems

These examples and the broader literature on path dependency show that a range of policy interventions, often initially quite modest and governing a limited population, can trigger one or more of the four path-dependent processes. They help us understand how policies became immediately "sticky" (DQ1), but also how entrenchment (DQ2) and expansion (DQ3) affected current approaches to some of the most important policy matters of our times. There is no reason then, a priori, why such process must remain "accidental" and/or can only be used to explain past events.

How might these path-dependent processes be applied forward to help decision makers find answers to the three diagnostic questions so as to ameliorate super wicked problems? Two general observations emerge.

First, our framework stresses the need to expand beyond mainstream policy analysis, which tends to compare a range of interventions and then models or estimates their (linear) effects, to consider non-linear and unfolding causal, yet, unpredictable, policy trajectories. Such a reorientation would, for instance, expand consideration of policy interventions to reduce US auto emissions from predicting the effects of gasoline taxes or other financial instruments on energy use to consider indirect, or unintended, effects of seemingly unrelated policies. One example of an indirect effect comes from unequal funding of K-12 education which, by relying on property taxes, creates incentives for middle and upper income families to live near well-funded suburban schools (instead of closer to their places of work), making these families highly car dependent and, as a result, leading to higher transportation-related emissions. This notion—paying attention to indirect or unintended effects—leads to unanticipated results but unlocks important opportunities for realizing behavioral change.

Second, our framework directs attention to not only the pros and cons of a given approach (such as in this case, funding education via property taxes) but also to different policy levels or orders (e.g., a small change to property tax settings to reward families with short commutes to work) or "layering" efforts (e.g., a statewide minimum per-student funding requirement). This reorientation also directs analysts to consider if easier-to-change or politically feasible policy settings exist that inform ahistorical or linear analytical approaches in ways to illuminate new approaches to addressing super wicked problems. For example, building codes, always dynamic by their very nature, may offer a

higher likelihood that changes will be accepted as the practice of the industry tends to be focused on applying, rather than fighting, regulatory requirements.

Once such broader interactions are brought into policy analysis considerations, our framework then directs attention to assessing not only immediate impacts on behavior, but on the plausibility that interventions might unleash one or more path-dependent processes capable of addressing our three diagnostic questions. Changing property taxes to promote shorter commutes will be insufficient alone. It is likely to only affect new families that are making decisions of where to live to raise a family not the many families that have already established roots in a given community. Hence, what matters is how this small policy interacts with other interventions to collectively create a progressive incremental trajectory attending to the super wicked problem in question. These insights implicitly reinforce Gunningham and Sinclair's (1999) call for "policy baskets" over single instrument approaches but also highlights the need to more carefully consider temporal interactions.

Building on these broad conclusions, what guidance can we provide to practitioners and policy scientists applying our framework? We discuss lessons that emerge by first addressing stickiness (DQ1). We then consider entrenchment (DQ2) and expansion (DQ3) together, since most interventions unleash processes that simultaneously affect them either negatively or positively. Our goal is to initiate, rather than conclude, a problem focused effort to develop new research questions for scholars and guiding strategies useful for practitioners seeking to ameliorate super wicked problems. To accomplish this, we illustrate how our framework reorients assessments of, and raises new questions about, a range of domestic and international efforts to reduce greenhouse gases through carbon taxes, cap-and-trade, and subsidies, as well as technological innovations.

Diagnostic question 1

This first question—what can be done to create *stickiness* (making reversibility immediately difficult)—directs policy makers to seek out and assess interventions that have the potential to trigger lock-in. Literature on path dependence offers several points of guidance.

First, analysts should review, and take advantage of, what is already sticky. This means understanding how highly durable constitutions and other hard institutions provide possible entry points for change. It also means assessing what sectoral factors, such as institutionalized resource allocation systems, shape and affect policy dynamics. In addition, analysts need to consider windows of opportunity that emerge consistent with the above institutional features. These windows are important as they can change the balance of benefits and costs for the adoption of a policy intervention at a given time. For instance, Rabe argues that a range of US state initiatives were successful because of the general political climate which supported the idea that something had to be done to address climate change. Rabe documents how a number of states initiated policies requiring that consumers be given the ability to choose non-fossil fuel energy options on electricity bills (Rabe 2009b). These efforts, once passed, appear to have become somewhat sticky owing to the US separation of powers,[11] which makes reversing policies much more difficult than other systems of government.

[11] Hence, a spike in US public support is more significant than in Westminster models of government because, once the window closes, policy reversal is much easier in the latter, as illustrated by Canada's 2011 withdrawal from the Kyoto Protocol.

Second, many of the interventions that responded to this window of opportunity worked "to minimize short-term political risk by delaying or obscuring cost imposition" (Rabe 2009a, 4). In doing so, they are able to lock in participation and, as we discuss below, ratchet up settings over time. It is important that such interventions do not legitimize low standards or worse yet lock in lower standards. Analysts will want to deliberate on whether interventions plausibly account for the political system's tendency to put off difficult and required behavioral choices in a way that the intervention can delay, for a period, required behavioral challenges by first entrenching the intervention and then the standards. It is beyond the scope of this paper to articulate the precise mechanics as to how such processes would occur—such an effort would be worthy of its own detailed analysis—but we do note that such results have occurred historically. Below, we reflect on how such efforts might be developed.

Third, analysts must examine the various points of access where lock-in might occur, rather than assuming that jurisdiction-wide legislation is the best venue. Scholarship on lock-in identifies various policy access points from where path-dependent trajectories have emerged, including sub-national jurisdiction, different policy-making units at a given level of government, and different levels or orders of policy. It may be that policy makers avoid anti-majority filibustering in the US Senate by focusing on Congressional committees that often address highly relevant, though less studied, calibrations and settings. Again, Rabe's analysis of US climate policy documents many cases where efforts to promote large-scale legislative changes failed, but, a range of smaller scale policies, many at the state level, took advantage of windows of opportunity that appear to have created some degree of stickiness.

It is important to note that stickiness, by itself, is unable to address the super wicked problem of climate change. If delaying costs explains support, then whether, when, and how the intervention might be successful depends on what path-dependent processes might also be unleashed. It is, therefore, critical that policy makers also attend to the second and third diagnostic questions discussed below.

Diagnostic questions 2 and 3

How might a protocol be designed to foster deliberations to entrench (DQ2) and expand (DQ3) policy interventions? At a broad level, we know from our above review that policy makers must avoid intervening to address and promote DQ2 if it is likely to make expansion difficult. More specifically, our review directs analysts to pay greater attention to the role of coalitions and values, deeply held views about right and wrong by segments of society, or policy norms that define and regulate appropriate behavior in particular circumstances. Both are initially outcomes of interventions (they act as "dependent variables"), but then, reversing causality, they often affect changes in policy settings, entrenchment of initial support, and support from expanding populations.

Coalitions

Converting short-term interests to the long term A key theme running through political science and related literature on policy development focuses on the importance of "winning coalitions" in which a diverse set of stakeholders come to support the same policy intervention, initially for very different reasons. A key question for our framework is how can support from such coalitions be entrenched and expanded to others? One such coalition, as documented by several scholars (Vogel 1995; Esty 1994; DeSombre 2000), is a

Bootlegger–Baptist coalition of business and environmental groups that all seek to expand regulations across jurisdictions. In addressing climate change, such coalitions have already come together in the development of voluntary climate registries. Environmental organizations see registries as a first step toward mandatory reporting of greenhouse gases and eventually mitigation policies. Industry recognizes that involvement in such registries is critical for recognition of early action to be rewarded by future mitigation policies. These coalitions contain a degree of lock-in because their goal appeals, for different reasons, to the strategic self-interest of environmental groups and business interests. More importantly, however, when successful in promoting increased regulations elsewhere, such coalitions create increasing returns as coalition members continue to benefit from championing increased standards in other jurisdictions. This, in turn, fosters positive feedback processes, since newly regulated firms have reason to join the coalition, as they too have a self-interest in expanding regulations elsewhere to create a level playing field.

Attention to generating such coalitions for super wicked problems is arguably as, if not more, important initially than substantive policy requirements. This is because they can set in motion a series of events that lead to higher standards once the coalition is entrenched and expanded. These events are not deterministic, which justifies careful attention by policy makers to nurturing the positive feedbacks, increasing returns and self-reinforcing processes that entrench and expand the basis of support for the intervention.[12] The trick for those seeking to trigger such processes is to carefully assess the suite of possible interventions that together have a plausible logic for expansion of populations covered and behavioral change. These interventions need to be parsed from others that, in the name of coalition building, entrench very weak forms of governance. Addressing and overcoming this dilemma is obviously a key question for the next generation of policy analysis devoted to super wicked problems.

A focus on coalitions also directs analysts to expand beyond treating the debate between carbon taxes and cap-and-trade as a question primarily of efficiency and administrative simplicity, which has led many economists to favor taxes (Nordhaus 2007). Policy analysts would want to assess which option is more likely to induce increasing returns and positive feedbacks for a core political constituency, and which option can increase that constituency. The lack of attention to these dynamics has rendered carbon taxes very difficult to put in place at the national level in the United States and Canada (Rabe 2009b), despite some success at the sub-state level (e.g., in British Columbia and Quebec in Canada) and in some European countries. Carbon taxes tend to create diffuse benefits and concentrated costs, which can produce stronger coalitions of opposition than support. With a few exceptions, noted below, policy makers have yet to innovate and create mechanisms that work to nurture coalitions of support.

Let us consider two illustrative examples that have paid attention to nurturing such support: the California cap-and-trade program and the British Columbia (BC) carbon tax. In California, just prior to adopting a cap-and-trade program, which is authorized under the California Global Warming Solutions Act of 2006, the California Air Resources Board

[12] For instance, the US Lacey Act, which was amended, with support from the American Forest and Paper Association and a number of US environmental groups, to give the Justice Department powers to seize wood products suspected to have been extracted, processed or traded in violation of another country's laws, has received stiff backlash owing to high-profile enforcement actions against Gibson Guitar. House representatives Jim Cooper (D-Tenn) and Marsha Blackburn (R-Tenn) introduced the bill Retailers and Entertainers Lacey Implementation and Enforcement Fairness Act (Bill H.R. 3210) in an effort to reel in the perceived ill effects of the legislation (see: http://thehill.com/blogs/e2-wire/e2-wire/188915-lawmakers-look-to-ease-lacey-act-regulations-after-gibson-guitar-raid).

(CARB) released a draft adaptive management plan that explicitly addresses unplanned adverse impacts from the regulations (California Air Resources Board 2011). In doing so, the proposed adaptive management plan accounted for the concerns of different groups that had contributed to the Board's consultation process, which appears to have helped legitimate the policy outcomes in the final board decision.[13] As a next step, our framework would guide policy makers to identify interventions that move from fostering expanded support to translating this support into increased standards and behavioral requirements. Hence, these efforts are important, but our framework calls for much greater attention to unfolding trajectory that involves more than one or two steps.

The BC carbon tax illustrates additional strategies for fostering a coalition of support but also the need for policy makers to further and consciously focus on unleashing a range of path-dependent processes. The BC government undertook two strategies that are consistent with our framework's attention to entrenching (DQ2) and expanding (DQ3) coalitions. First, it took advantage of its strong ties with business interests by developing a revenue neutral tax policy[14] which fostered swift entrenchment through increasing returns by benefiting a core constituency.[15] Second, calibrations focused on sharing tax revenues with municipalities and school boards that had committed to carbon neutrality (Harrison 2009). These policies, whether intended or not, created increasing returns logics aimed at an expanded population, which in turn, we can plausibly expect to have positive feedbacks on the original supporters. The decision to tie these taxes to school boards also created additional stickiness through coalition building since municipalities and schools would lose considerable revenues if the tax was ever rescinded. Beyond these strategies, our approach offers additional ideas that the government could have considered. For instance, there is a plausible logic that the coalition would have been further nurtured by communicating to populations the increasing returns benefits they might enjoy, but of which they might not have been immediately aware. By making more obvious the link between the carbon tax increases and cuts in personal income taxes, such communication might have reduced pockets of societal opposition, which the opposition party exploited.[16] There is evidence these lessons are being applied by some policy makers adopting the framing of "cap-and-dividend" rather than "cap-and-trade."

Whether the efforts of the California Air Resources Board and the BC tax will prove effective will, in part, be answered by whether other interventions can be nurtured to intersect in ways that create increasing returns and positive feedback processes within these jurisdictions, North America, and globally. The point here is that policy makers must not only work to influence multiple jurisdictions, but also multiple access points that might

[13] For instance, a representative of NRDC reflected that the adaptive management plan "…adds legitimacy to the FED [Functional Equivalence Document]" for the impacts of the cap-and-trade rules to do with forest offsets and negative impacts on air quality. See Letter from NRDC to the Air Resources Board, December 16, 2010. Available from: http://www.arb.ca.gov/lists/capandtrade10/1230-alex_jackson.pdf.

[14] In Premier Gordon Campbell's 2007 throne speech, he committed to reducing greenhouse gas emissions in the province by 10 % under 1990 levels by 2020 (Campagnolo 2007). A carbon tax of $10/tonne to increase $5/tonne each subsequent year was then passed in July 2008 (Ministry of Small Business and Revenue 2008).

[15] In fact, the Liberal Parties strong ties to business arguably paved the way for such coalition building. It is unlikely that the same intervention could have been pursued by the opposition New Democratic Party, which aligns itself with environmental and labor interests in the province (Harrison 2009).

[16] The carbon tax increases were matched with a proposal to cut 2 % in personal income taxes for those in the lowest two tax brackets in 2008, progressive incrementally increasing up to a 5 % cut in 2009 (Ministry of Small Business and Revenue 2008).

provide greater feasibility in affecting initial changes and contain underexplored possibilities for triggering one or more path-dependent process.

Finding ways to entrench existing population while creating incentives for expansion will most certainly be challenging, since most efforts at entrenching coalitions (DQ2) appear to work in ways that make expansion difficult (DQ3). For instance, well-intended efforts to entice businesses to support climate efforts often pay insufficient attention to promoting positive feedbacks, resulting in what appear to be blocked entrenchment processes. Companies such as BP and Shell were early proponents of flexible market mechanisms in the UNFCCC negotiations and in the development of the UK and EU emissions trading schemes. After breaking with the Global Climate Coalition—a business lobby opposing climate policy—in 1996, BP worked with the Environmental Defense Fund to develop an internal emissions trading scheme. BP and other companies were at the table to ensure their experiences and existing emissions reductions were accounted for in any future government regulatory program (Meckling 2011). They thus supported maintaining the intervention given that they were early adopters who had the opportunity to shape and be rewarded by future policy. However, BP, Shell, and other oil companies still have an interest in fighting climate policies that operate against their core business,[17] which works to limit which policies are politically feasible to pursue to create positive feedbacks to expand coalitions of support (DQ3).

These countervailing pressures have important practical implications for assessing currently unfolding events governing climate policy. The financial sector, for instance, is frequently discussed as a central constituent of the pro-trading coalition (Meckling 2011; Newell and Paterson 2010). But unlike BP, which benefited from influence over the rules and possible credits for early action, the financial sector's ability to benefit seems closely tied to the size of the market. The larger the market, the more opportunities to trade, which in turn, might create the ability to ratchet up public policies over time in ways that reward market participants. Further engagement of these actors in the policymaking process might assist in gaining broader support for public regulations.

Finally, in order for policy makers to avoid playing a game of "whack-a-mole" between the interests of initial supporters (DQ2) and of prospective future supporters (DQ3), they will need to carefully consider the trade-off between the value of harmonization—economies of scale and lower transaction costs for international trade—and the value of learning and competition that derives from variation in emerging technologies or institutions. An illustrative example of this challenge is the impact of different standards for wind turbines: there is a 30-ton difference in the weight of the tower for the V-90 3MW turbine between the international "IEC IIA standard" and the German-only "DIBt II" standard. This creates interoperability problems and potentially slows the diffusion of this low-carbon energy option, which is critical for addressing DQ3. Certification requirements are also especially important for the services sector that is emerging around cross-border wind energy value chains. Globally operating firms that provide services like wind site assessments, financial due diligence, or project development services often face very high entry barriers in the form of approval processes and requirements to cooperate with local firms

[17] For instance, BP and Shell have both been lobbying the UK government to oppose the EU's proposed fuel regulations, which would penalize unconventional sources such as Canada's oil sands by assigning this crude oil a higher carbon footprint than conventional crude. Thus, even though BP has supported climate change policy, the company does not benefit from all initiatives which advance this agenda. This means policy makers must be careful to identify the reasons different actors are in a winning coalition and the situations when those actors may or may not support the policies that ratchet up action to address climate change. http://www.guardian.co.uk/environment/2011/nov/27/canada-oil-sands-uk-backing.

and government agencies. Hence, policy makers should find ways to prevent disharmony among technical standards and regulations from creating barriers to the longer-term effectiveness of policy interventions to address climate change.

Creating new interests in line with super wicked problem In addition to reorienting short-term interests by promoting coalitions that unleash path-dependent processes, another strategy seeks to create new interests whose very identities align with ameliorating the super wicked problem. While a range of possibilities can be explored, our review of the QWERTY keyboard example points to an underemployed strategy: the role of training and education programs in fostering new coalitions (DQ3) that reinforce smaller support (DQ2), creating increasing returns and positive feedbacks. Training and education might open up possibilities because they focus attention both on creating new education institutes (whose costs might make it difficult to start but also create immediate stickiness through sunk costs) and changing settings and calibrations of existing education institutes by mandating certain types of training within the curriculum. The trick is to understand what types of training are more likely to become entrenched, creating lasting effects on graduating students.

Strategies to consider include providing education resources for specific skills, such as installing solar panels, which would create positive feedbacks for the solar industry while creating an increased number of individuals who seek increasing returns in the form of jobs or wages through green technologies. The creation of training schools on solar panels, while seemingly independent, works to reinforce policies aimed at having an increasing number of people adopt and use solar panels. This intervention might rather quickly create a powerful constituency of trained workers to support further policy interventions promoting green technologies. Training would, therefore, no longer only help businesses and create employment, but it would also create increasing returns and positive feedback (DQ2 and DQ3) to address a super wicked problem.

By considering these possibilities, policy makers need to evaluate all policies for whether they are expected to impede or hinder creating these new actors and interests supportive of progressive incremental policies. This points policy makers to consider not just firms but also the individuals who work on the design of carbon markets, work in NGOs, advise companies, or lend support from within government at various levels, all of whom can become an integral part of a policy community supporting a ratcheting up of the market before it even reaches the legislative agenda (Paterson 2012). We can imagine, as Rabe documents, that when US states required utilities to give consumers the option to buy renewable electricity, a new interest group emerged to represent consumers that voluntarily purchase renewable energy. The key question then becomes: will this initial support pave the way for learning about consumer behaviors, which could facilitate mandatory approaches later, especially if increasing returns incentives can expand the base of support while creating positive feedbacks to amplify the support of those groups initially backing the intervention? A critical question, of course, is how quickly learning can occur so that support can be increased at a meaningful rate.

Creating new interests also reinforces a focus on coalitions. It guides policy makers to consider how interventions might trigger positive feedback or self-reinforcing processes that change the political landscape in the future by nurturing *new* actors and organizations that have an interest in low-carbon trajectories. For example, when new carbon markets begin, new groupings of actors are created, including investors and banks that profit from carbon trading, firms that learn they can benefit by participating in the market, and possibly

sectors that learn they can benefit after the system is in place. This could include farmers who can sell carbon offsets by changing to lower-emissions agricultural practices (e.g., planting in a way that does not require tilling). Although it was defeated, this may be what the framers of the Senate American Power Act bill had in mind with its support for an agricultural offset program (Sec. 734, 2.b.L). What is crucial is that policy makers develop interventions that will not only remain durable over time and require targeted populations to change behavior, but also those that are likely to expand the community benefiting from the intervention. Creating new interests may also help offset opposition that might occur. It may be, for instance, that since a group that will lose from a climate change policy action will be organized and ready to lobby against change (Unruh 2002), one policy response might be to approach the problem from a different direction, building increasing returns in a separate "niche" before expanding the program.

Illustrations of this logic come from the extensive literature on technological pathways. While never easy tasks, we do know that government policy has long spurred technological innovation and path dependencies, as the above-mentioned light water nuclear technology example illustrates. Nurturing such policies requires considering a range of interventions and assessing their hitherto overlooked benefits. For instance, procurement policies surrounding the light water nuclear energy program did much more than simply allocate government funds. Rather they served to trigger a specific technological path that can be characterized as immediate lock-in owing to sunk, investment costs. Importantly, this policy continues to influence today's behavior without ever going through the legislative process. Likewise procurement policy played a similar role in supporting gas rather than steam turbines for aircraft engines (Islas 1997) by creating immediate economic benefits to those producing this equipment. It is important for the super wicked problem of climate change that such interventions benefited from but did not rely solely on immediate stickiness. Instead, they helped buy time so that other path-dependent processes, including increasing returns economic benefits for firms that switched to provide this technology, could kick in.

One challenge is that policy makers must find ways to avoid creating progressive incremental support for technological losers. Given the unpredictable nature of policy interventions governing super wicked problems, this cannot always be avoided. However, conscious deliberations to avoid policies that are quite likely to do so are important for governing super wicked problems. Kemp et al.'s study found that government actions to support a particular technology can be expensive and destructive (Kemp et al. 2001). They point to the state of California's early efforts to promote wind power in which subsidies aided the production of cheap, but poorly performing technology, and perpetuated the myth that alternative energy is not as reliable or consistent as traditional fossil fuel-based technologies (Kemp et al. 2001).

One way potentially around this comes from Kemp et al. (2001, 280) who argue that policy makers ought to deliberate over steering socio-technical change in general rather than picking a given technology. In Germany, for instance, the government provided research and development subsidies to support variation in wind turbine design. This approach positioned Germany well, through increasing returns, to benefit from a soon-to-expand market for wind energy. Also, compared to other EU countries and the United States, the German feed-in-tariff program provided stickiness for an initial group by creating greater immediate financial benefits to investors, allowing them to benefit from increasing returns when the market expanded (Walz 2007). This intervention, then, has had increasing return effects for wind energy producers and has helped foster a winning coalition needed to facilitate ratcheting up policies in the 1990s and beyond.

Important lessons for nurturing climate-friendly technologies emerge. First, incentives or information that facilitates thresholds being surpassed more quickly appears to be a promising direction for policymaking to pursue. Hence, municipal or public procurement may create a large enough market for alternative technologies that contain some logic for helping "tip" the viability of alternative, environmentally friendly technologies. This might come in the form of establishing low interest loans/grants for the independent development of low-carbon technologies that bolster strong increasing returns and associated positive feedbacks for the set of early adopters (DQ2 and DQ3). Second, and complementary to coalition building, support for technologies can be used to win support for a broader package of climate change policies. Perrow proposes this in advocating that the US support carbon capture and storage research as a way to overcome resistant to climate change legislation among coal-dependent states in the US mid-west.[18]

Values and norms

Beyond attention to fostering short-term, self-interested coalitions, our approach also directs analysts to consider how norms and values might play a role in policy trajectories, either as initial triggers or by creating self-reinforcing, increasing returns, and positive feedback processes that generate "logics of appropriateness" uniting and expanding a political community.

Fostering norms holds potential for addressing super wicked problems because they create self-reinforcing processes within international and domestic policy-making arenas. Norms diffuse across populations owing to increasing returns (the benefit of social cohesion) and create positive feedbacks for those early norm entrepreneurs. A focus on norms, moreover, responds to the challenge of fragmented authority and the challenge that those creating the problem are trying to solve it as norms contain an ongoing logic for expansion, much the way slavery and colonialism, in contrast to norms of 100 years ago, are now deemed unacceptable by the vast majority of societies and countries.

Attention to norms is important for thinking about how to unleash pathways where benefits need not only be targeted to monetary factors. Instead, analysts must focus on how they might be able to draw on processes of learning, routinization, and adaptive expectations to trigger positive feedbacks by engraining choices within cognitively accepted cultural expectations of appropriate or legitimate behavior such that they are harder to undo (Mahoney 2000; Nelson and Winter 2002; Mintzberg 1978). There is no question that such processes, though understudied, can and do occur. Hacker's research on US health care policy cited above found that the pathways he documented eventually resulted in a change in attitude among conservative House and Senate Representatives, further reinforcing a private over public system. Legislators' expectations shifted over time so that they came to see private health care as preferable to a public system, even if government money was necessary to fund it (Hacker 2002, 227).

Accounting for norms and learning requires that policy makers consider which interventions are more likely to lead groups to adapt their expectations in ways that mean the original intervention becomes accepted as appropriate (i.e., legitimate). There is already some evidence of this occurring, since energy policy is increasingly thought of in terms of carbon intensity, in a way it had not been before climate change gained salience. Such a shift was clearly the intention of the Senate's American Power Act bill, and non-state

[18] http://www.bloomberg.com/news/2011-10-23/technology-can-nudge-climate-change-politics-charles-perrow.html.

efforts such as the Carbon Disclosure Project. Similarly, we are seeing a cognitive shift to thinking of carbon dioxide emissions in terms of price and as a commodity, which though completely constructed, stems from a focus on the proliferation of attempts to build carbon markets at multiple scales. Our point is that although some of these impacts were largely unintentional, policy makers may be able to intentionally steer or create new norms of appropriateness; however, they also must be sensitive to framings that invoke or support counter coalitions or that do not win over individuals or groups with cultural frames that pre-dispose them to climate skepticism (Hoffman 2011).

It is important to note that the literature recognizes that engrained norms, such as the shift against slavery or public smoking, often result from progressive incremental changes that can take decades or centuries to occur. Hence, while useful, our approach cautions against a focus on such norm changes when there is no "plausible logic" that they will yield transformative changes in line with the "time is running out" feature of super wicked problems. In this context, three relevant literatures offer guidance on how to unleash values and norms that can trigger swift progressive incremental trajectories.

First, organizational strategy literature (e.g., Suchman 1995) has found that strategists can "leapfrog" over slow progressive incremental change processes by mirroring new interventions on approaches that already enjoy normative support. Second, research on advocacy coalitions and learning (for a review, see Sabatier 1998) shows that stakeholder deliberations that foster "policy learning" among otherwise polarized groups with very different "deep core" values can change their "secondary core" beliefs about effects of instrument choice, opening up policy innovation and unblocking policy log jams. The challenge for this literature in particular, and multi-stakeholder processes in general, is to find ways to promote stakeholder learning that move away from an emphasis on achieving consensus, which militates against addressing super wicked problems. It suggests reorienting their focus toward problem definitions that draws on scientific knowledge, rather than problem definitions narrowed or shaped by the strategic self-interests of powerful actors.

Third, research on change and stability of policy "subsystems" (Hall 1993) has focused greater attention on distinguishing different types of learning processes for changing values. For example, Hall hypothesizes that changes in policy settings and objectives can occur endogenously within the subsystem, while changes in overarching goals (such as Keynesianism versus Monetarism) usually get reinforced and reproduced in policy subsystems and only change from some type of societal learning process. Recent advances in this literature have highlighted the need for greater attention to understanding the precise mechanisms through which values change and influence different levels of policy, including "real world" instances in which goals changed through endogenous processes (Cashore and Howlett 2007).

These findings suggest that the next generation of super wicked policy analysis should design interventions to shift values by consciously and proactively initiating learning processes. Rather than taking political feasibility as fixed, further probing these literatures may unlock new possibilities for progressive incremental policy interventions in future time periods.

Conclusion

This paper has attempted to redirect social science examinations of climate policy away from traditional ahistorical policy analysis techniques that seem ill equipped to address

super wicked problems, and to expand from explaining past events to apply analytic lenses forward. This led us to focus policy prescriptions away from (often misdiagnosed) single-shot "paradigmatic" policies or solutions that are currently "politically feasible" but woefully inadequate. The former can either paralyze actors vying for policy change given the lack of opportunities to achieve such policies or unintentionally create new countervailing efforts that, over time, work against the reduction of greenhouse gas emissions. The latter have tended to be inadequate to generate the necessary momentum or levers for the transformations of behavior and economic activity necessary to combat climate change. We argue that, while well-intended, existing policy-oriented work leaves unexplored a third option that builds on an understanding of path-dependent causal processes. We suggest this reorientation is critical for addressing the tragedy of super wicked problems: even when we collectively recognize the need to act now to avoid future catastrophic impacts, the immediate implications of required behavioral changes overwhelm our collective interest in policy change and the ability of the political and policy systems at multiple levels to respond.

Turning work on path dependence on its head, we have used an applied forward reasoning approach to identify three questions for policy makers to consider that are designed to address the tragedy of super wicked problems. We have identified a few illustrative examples for ways decision makers can assess interventions through an applied forward reasoning approach invoking path dependency analysis. By considering how such choices may trigger progressive incremental steps, these policy choices are cast in a new light. Our framework shifts the analytic lens to how policies might become entrenched and the causal processes through which they can ratchet up behavior over time to be commensurate with the scale of the problem we seek to address. We believe that this, and future refinements, may help uncover innovative policy solutions that otherwise would have remained hidden beneath the vast numbers of ideas emanating from traditional forms of policy analysis.

Our attention to "progressive incremental" pathways incorporates, rather than bypasses, the first feature of super wicked problems—that time is running out. We see interventions as needing to both foster one or more path-dependent processes and contain a clear rationale for sufficient and timely behavioral change consistent with the scale of the problem. In other words, paradoxically, while super wicked problems involve a race against the clock and a collective irrational time-preference, progressive incremental trajectories may present an important resolution to the conundrum that avoids the trap of pursuing the apparently "one shot" logical solution.

We have stressed the need to embrace, rather than reduce, historical forces that shape politics and outcomes. Instead of treating history and politics as inefficient, our framework directs attention to how such forces may in fact open up creative solutions to address super wicked problems. The focus on coalitions and norms/values highlighted some of the ways in which a path dependency approaches yields new insights and questions regarding long studied policy interventions with examples from current efforts to address climate change. Our point here was not to provide definitive conclusions and policy recommendations, but to call for greater attention on the part of policy scientists and traditional policy analysts to these questions.

The challenge for applying this forward is that most path-dependent processes tend to occur only by accident, and they are just as likely to exacerbate, than solve, super wicked problems. It is only by deliberate efforts to entrench these insights into mainstream policy analysis, and then to evaluate those interventions that have plausible logics for reducing greenhouse gas emissions, that we may be able to collectively harness the policy logics we identify to ameliorate what is arguably the most super wicked problem of our times.

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