An Experimentalist Approach to Governing Global Climate Change

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NOTE: this is a work in progress and comes with all the caveats of a draft. Please do not circulate.

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CHAPTER I. Introduction

After decades of false starts, serious efforts to address the problem of global climate change now seem under way. The commitment to act, although highly variable, seems to be shared by most of the world's largest governments. A growing number of firms and industry associations are refocused on the need for action. NGOs are highly mobilized. But that commitment must now lead to practical actions. The knowledge about which actions will work is growing, but it is highly decentralized. Yet any serious solution to the climate problem will require international cooperation—a task that is hard to achieve when the relevant actors and information is scattered around the global economy. This book is about how that scattering can be focused in more productive ways—to yield, in time, a highly effective approach to international cooperation.

The need for collective action is visible everywhere in the international system. The logic of global public goods demands global coordination to solve free-rider problems. The logic of tragedies of the global commons demands coordination to reconcile the interests of those who use the common goods. It is hard to see how solutions will emerge to the most pressing global problems—such as climate change—without effective and coordination of policies on many scales.[2]

Coordination can emerge in different ways. It can result from integrated, purposeful efforts to align the behaviors of key players—top down. Or it can emerge in a more decentralized fashion—bottom up—from a myriad of more localized and focused efforts at problem solving, some of which prove effective, diffuse, and can be scaled up into encompassing structures that encourage further initiatives.

The top down world has long been assumed as the first best strategy for solving serious global problems. It takes for granted which players should be at the table and that those players know their interests and capabilities. When the US and the Soviet Union set out to cap the volcano of strategic armaments they didn't rely on lots of decentralized actors to figure out what might work. Instead, elites from the two governments sat down and bargained directly. The results were integrated, top-down treaties aligned interests where possible and enforced key obligations where necessary. In some areas coordination was so simple and straightforward that no formal agreements were.[3] Or, the agreements were simple yet highly effective— after the Cuban Missile Crisis the US and the Soviet

[2] Morse and Keohane 2014; Patrick 2008; Hale, Held, and Young 2013; Keohane and Victor 2011; Barrett 2006.
[3] Schelling and Halperin 1961; Downs and Rocke 1990.

Union quickly concluded an “hot line agreement” to provide secure and reliable communications in times of crisis.

Similarly, the keystones in international economic coordination were top down bargains that governments could readily draft. Most famously, at Bretton Woods 733 delegates from 44 countries literally sat around tables for 21 days and crafted major economic institutions that have endured from 1944 to today. Since then, most trade negotiations have followed similar models—with each round of talks beginning with an agenda and each participant agreeing, ultimately, to a single, integrated undertaking. The biggest impacts of trade liberalization have come from the simplest agreements that were relatively easy to reach and largely self-enforcing because they were conspicuously in the self-interest of the major countries. Big reductions in tariffs and the extension of most favored nation treatment to all members of trade agreements were enforced by reciprocity; violations were relatively easy to spot and understand.

While prized as the best way to solve global coordination problems—because it is strategic, comprehensive and integrated—top down is very demanding. It can only succeed if the key actors know, *ex ante*, where the system should be headed and how best to get there. That requires that they understand their interests and can agree on some distribution of costs and benefits where interests are not aligned. Where critical information is lacking or the complexity of deal making is overwhelming, essential players may be unwilling or unable to coordinate their behavior. Thus bottom up strategies have long been a fallback position in international cooperation. When the US and Soviet Union could not agree top down to stop atmospheric nuclear testing, a fallback, tacit bargain to stop that behavior emerged. The Soviets and then the Americans just stopped testing for a time. In trade, as big rounds have become more complex and difficult to reach a host of regional and other smaller agreements have been forged to fill the gaps.

Most diplomats habitually seem to treat strategic bargaining with a common, integrated purpose as Plan A. Failing that, a distant plan B envisions that countries and other key players cobble together what they can, where they can, and progress. But habit aside the ranking of plans should depend on the context. Integrated bargaining makes sense in settings where uncertainty is low—*ex ante* knowledge of means, ends and preferences is reasonably complete—and bargaining costs are correspondingly low. That kind of bargaining requires, as well, that negotiators be able to represent reliably the interests of their constituents and make deals that they can implement reliably at home. By contrast, where uncertainty is high they key actors, unsure of what outcomes are possible, cannot confidently specify their own interests. Nor can they accurately predict and shape with penalties and rewards the interests of others. In such settings, cooperation requires active efforts to reduce uncertainty and to learn what is feasible. Experimentation through policy trials and incremental, joint

learning are better means of advancing.[4] In Plan A the proverbial "bargaining table" is actually a table that can take many different shapes. In Plan B, the "bargaining table" is a workbench where the key actors cobble together solutions through trial and error.

This same debate has unfolded in climate change over the last 25 years. Following the logic of plan A, diplomats have sought a strategic, integrated, legal binding agreement focused on the problem of global warming. This approach treats the United Nations as a having a monopoly on legitimacy—and relying on the UN-sponsored Framework Convention on Climate Change (UNFCCC) as the exclusive venue for diplomacy. The governments and other stakeholders that want serious action on climate change have invested massively in Plan A. Many theorists have gone along for the ride. At first they tried to explain the conceptual attractions--indeed necessity--of global, top-down coordination. As those schemes failed, increasingly they have sought to demonstrate why the misalignment of incentives meant that diplomatic efforts were bound to fail.[5]

For many years, the faults of Plan A have been surfacing—most strikingly in 2009 at Copenhagen, when countries even failed to agree formally a plan for further negotiations.[6] Climate is hardly alone. In trade, the aim for an integrated global agreement—launched in 2001 at a meeting in Doha—has led to gridlock as well. [7] Plan A efforts at grand treaty making on sustainable development, human rights and other topics are also running into trouble. [8] There have been some successes in, for example, financial coordination—but only in the face of massive financial failure.[9]

Plan B, a bottom-up strategy, has emerged to fill the resulting vacuum. For most governments and policy advocates deeply steeped in the politics of climate change, this new approach is more a fallback position than a strategy. It is seen as a local intimation or imitation of the stalled global solution. It is defined more by what it is not—the failed top-down effort—than by a clear understanding that decentralized governance, by fostering on-the-ground problem solving and learning, may be able to address problems that more encompassing integrated policy regimes cannot. Plan B is a default after two decades of efforts around Plan A have failed; it is not understood as the best route for informing and changing the politics of bargaining such that more effective agreements become

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[4] Axelrod 1984; Ostrom 2009; De Búrca, Keohane, and Sabel 2014; Victor 2009b; Camerer 2003.
[5] Barrett 2006.
[6] Victor 2009a.
[7] Zedillo 2007.
[8] Hafner-Burton 2013; Hale, Held, and Young 2013.
[9] Drezner 2014. For more on the role of delegation to a special class of private actors in the realm of financial coordination see Büthe and Mattli 2011.

possible with effort. Nor has it helped that early instances of bottom-up diplomacy on climate change have been advanced by countries whose underlying intentions around real problem solving were suspect or manifestly pretextual, as when the George W. Bush administration tried to stitch together a coalition of willing supporters for an Asia Pacific Partnership (APP) after the President hastily withdrew from the Kyoto Protocol in 2001, just months after taking office.[10]

This book makes the case for Plan B. We focus on the case of climate change, arguing that decomposing the grand, sprawling challenge into discrete problem solving efforts that engage ground-level actors *could* be highly effective—indeed, much more effective than bargaining around integrated global agreements. We see this bottom-up, decomposed effort not as a backstop Plan B but as the proper, central strategy for responding to the global problem. It is not a consoling alternative to failure—a device adopted in Paris late in 2015 to avoid a repeat of the Copenhagen debacle—but a superior way to coordinate action in the face of massive uncertainty about the interests, capabilities and intents of the key players. It is not a time-consuming detour on the way to the main goal but rather the only viable path to achieving radical transformations in national policies that lead to deep cuts in emissions.

Thus, in this book, we cautiously celebrate the first steps toward a bottom up approach in Paris. Many of the elements for an effective system of incremental learning were formally built into the final agreement from the Paris climate change conference. Countries were encouraged to make their own pledges—known eventually as nationally determined contributions (NDCs)—and to document what they learn. A system of review would check progress periodically, and a regular "stocktaking" would help adjust overall goals and expectations. Countries' goals will thus naturally reflect their interests and capabilities. They will therefore be more motivated and willing to pursue them energetically then they have been to reach targets assigned formulaically from above.

But we worry that "bottom up" is today's favorite flavor out of despair, not because the parties have grasped why and how a decomposed, bottom-up approach would be best under current circumstances. Indeed, while many of the elements of a successful system were adopted in Paris, it is sobering that most

[10] The same can be said of the Major Emitters Forum (MEF), which was renamed in 2009 as the Major Economies Forum (MEF) and charged with building political momentum for the late 2009 Copenhagen Conference of the Parties. It continues to operate. With either proper name, the acronymed MEF became a club for talking about problems and focusing action on other forums, notably the UNFCCC, but not doing much itself.

of the difficult choices—such as how to impart rigor into the NDCs and the review mechanism—were deferred until later. [11]

Thus in addition to focusing on climate change, in this book we also aim to outline a theory of how governance through experimentation actually helps societies solve complex problems by breaking them down into more tractable pieces, while maintaining enough connection among the separate efforts to allow mutual learning and assessment of overall progress. We will articulate the conditions that must be satisfied and thus help, we hope, diplomats and other stakeholders that want to make more effective this new approach to managing climate change.

The fallback position is on the agenda—indeed in Paris *became* the agenda—because climate change is marked by two, intertwined sets of characteristics that make integrated, top-down bargaining all but impossible. The first are political: the fragmentation of power and authority in the international system, and the corresponding absence of a hegemon that can reliably impose order on actors with sharply divergent interests. Hegemonic decline, of course, has not led in lockstep to the decline of existing international institutions. But in the absence of a hegemon the challenges of building new institutions or substantially reforming old ones are daunting—especially when the most powerful nation, the United States, is deeply divided on the need for effective climate change policy.[12] For the last two decades the EU has led many efforts to craft international institutions on climate change. EU leadership has been ambivalent, sometimes focused on failed attempts to create integrated top-down treaty systems, sometimes on more successful efforts at sector-by-sector, bottom-up strategies. But US irresolution may well be strengthening the EU's resolve.

The second are cognitive: uncertainty about the feasibility of achieving policy outcomes, such as lower emissions, at acceptable costs. This uncertainty explains the inability of any country or firm that takes deep decarbonization of emissions seriously to identify *ex ante* what behavioral, technological and regulatory commitments will actually prove most effective. The big challenges to cooperation on climate change are not merely that countries have diverging interests and some unwilling to pay anything for collective action. It is that even the clubs of countries that favor action don't know what that action will cost or how it can be organized in ways that stay aligned with shifting national interests.

This shroud of uncertainty about the actual burdens of various commitments exacerbates the bargaining problems that arise as diplomats seek to coordinate national policies. Those bargaining problems, in turn, heighten the sense of uncertainty as key parties cannot anticipate—and must fear—how counterparts

[11] Victor 2015.
[12] Keohane 1984; Victor 2011.

will react to the frustration of expectations.[13] If it is unknown at the time of bargaining which commitments really can be fulfilled and how others will respond if some are not, bargaining among parties with sharply different interests will be highly complex and cautious to the point of paralysis. Risk-averse players will prefer deadlock and inaction to a risky codification of ambitions that may prove too costly or simply unattainable.[14] Or they will prefer shallow agreements—those for which compliance is trivial even without an active change in behavior—as happened with the Kyoto Protocol.[15] By focusing on legally binding contracts—treaties—these tendencies to deadlock or Pabulum are further enhanced since most countries take their legal obligations seriously and do not willingly join such contracts without a coherent plan for compliance.[16]

Decomposition, we argue, is an essential first step in breaking this vicious circle. An active strategy is needed to decompose the global problem into component problems areas. The global problem is so complex that it is unmanageable and daunting. But it can be reduced into more discrete problems—such as reducing the deforestation associated with increased cultivation of palm oil, or cutting the emission of greenhouse gases (GHG) produced by vehicles, or demonstrating the viability of new forms of electric power plants that have low or negative emissions—that are easier for real governments, firms and NGOs to understand and implement, and closer to their immediate interests. In practice, this means focusing on sectoral, local and regional governance arrangements that encourage disciplined, inclusive problem solving by competent actors. This focus directs attention to urgent, localalized problems – – such as reducing smog or black soot – – where early successes can produce short-term political and economic benefits, while simultaneously building a coalition in support of long-term action and providing the information needed to guide it.

We draw from the idea of experimentalist governance (XG) to show how actors facing uncertainty can institutionalize a process that allows them to work practically on these decomposed problems. They experiment with solutions; the bolder the experiments the more uncertain the outcomes. As they learn what works and scale up those solutions they also learn how to manage the uncertainty in the international bargaining process, how to connect short-term and long-term goals. More complex deals become feasible; more effective and deeper cooperation emerges.

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[13] Young 1989a; Young 1989b.

[14] Abbott and Snidal 2000; Hafner-Burton, Victor, and Lupu 2012.

[15] Victor 2001; Almer and Winkler 2017.

[16] On countries taking their obligations seriously see Chayes and Chayes 1998, a point underscored even in studies that are skeptical about the impact of international law (Goldsmith and Posner 2006). On the tradeoff between bindingness of commitments and depth see Abbott and Snidal 2000.

Put differently, XG is an iterative process that allows actors to jointly explore the practicalities of realizing their overarching, framework goals, adjust the latter when necessary—and in this very process to update priors about what is feasible and who is reliable in light of evidence.[17] XG emphasizes that regulator who sets goals and regulated obligated to meet them rarely know what is feasible when they begin to tackle a problem; it prizes a diversity of efforts rather than monopoly. It identifies and continuously improves solutions that work—and pushes them to scale—while siphoning resources away from those that don't.

XG is not a starry-eyed utopia in which regulators and regulated entities always learn and apply the right lessons. Rather, it is a view of regulation animated by fear of worse outcomes. Centrally, XG relies on a penalty default such as prohibiting access to a market or the imposition of onerous regulations. When a penalty default is in place actors face a choice between cooperating to devise a solution or suffering an outcome – – the default – –none is likely to prefer to a jointly elaborated alternative. The penalty default thus induces cooperation and exploration where they are not spontaneously forthcoming. Penalty defaults can arise through public decision-making, such as threats from governments to sanction firms or remove access to markets if a problem is not seriously addressed and (incrementally) solved. Or they may emerge from private, corporate initiatives, when large firms impose standards on their suppliers as requirements for doing business, or from civil society initiatives such as threats of boycotts of noncompliant branded products. In this book we will show that the line between "public" and "private" is fuzzy and that the most likely sources of effective penalty defaults vary with the structure of industries.[18] Penalty defaults can emerge through agreements by clubs of actors or by the unilateral decision of a powerful actor. Whatever their origin penalty defaults create strong incentives for innovation of possible solutions, experimentation, and then widespread application of the solutions that prove most feasible and efficient. The persistent shadow of penalty defaults helps keep that process of innovation focused on outcomes that actually help solve problems.

The chief value of XG is that it institutionalizes decentralized, bottom-up efforts to control global warming emissions. It lowers the risks of paralysis and indecision that have been evident as governments have sought global, top-down solutions. But left to themselves disconnected, decentralized efforts at problem-solving can be aimless and impotent. XG creates institutions that encourage and support local exploration, but also coordinate and generalize its results. XG breaks the circle of cognitive and political bargaining deadlock practically: By facilitating

[17] Sabel and Zeitlin 2012.

[18] This point is familiar to students of corporate social responsibility and other behaviors of firms motivated by fear of penalty outcomes. Brand-conscious firms are affected by fear of private consumer action. Firms in commodity industries are less motivated by such concerns—but can be influenced by public decisions such as threats of sanction or loss of market.

rapid improvements in the understanding of what can be done, experimentation and learning narrow the zones of uncertainty and make risks more manageable; that in turn helps parties better understand their political interests and offers stepwise solutions to initially insurmountable political barriers. Put another way this approach lowers the costs and increases the returns to exploration, incentivizing participation in areas of focal concern and creating demonstration effects and other spillovers that propagate successes.

We are mindful that our views about XG will sit very uncomfortably with policy makers and scholars who, for decades, have been arguing that government is incapable of efficiently mustering the information necessary to regulate complex problems. Market-based strategies, instead, are needed. Our view is that markets can be powerful tools for mitigating climate change, subject to two provisos. First, markets in environmental goods are better at delivering static rather then dynamic efficiency: making the best use of resources *given* certain constraints, rather than changing the constraints themselves . This is because investments in particular kinds of technology tend to be self reinforcing. Developing and installing the first round of "dirty" equipment makes it cheaper to install the next. Special, costly efforts are needed to develop alternatives, and regulation and institutions can substantially reduce those costs. The success of the SO_2 trading regime in the United States—which probably remains the world's most successful large-scale emission trading system now that Europe's climate change trading system has spiraled into existential troubles—was built on a prior round of innovation in scrubber technology developed through XG type collaboration among firms. Once firms knew about the range of their technology and behavioral options then the cap-and-trade system made an indispensable contribution to static efficiency. The second proviso is that markets—whether carbon taxes or emission trading schemes—are the result of political processes. Those politics are vulnerable to uncertain outcomes that important interest groups might not favor. Where those outcomes can be narrowed markets can be designed to generate emission reductions with high static efficiency. Where not, the political process will favor market designs that reflect the dominant interests.

The concept of XG was developed through the study of the response of both firms and public administration in the US and EU to problem of regulating uncertainty.[19] A central contributions of this book is to build on this work and extend the logic of XG to international governance.[20] We explain how experimental, fragmented governance schemes *could be* the first best approach to addressing climate change internationally, rather than an unwelcome surrogate. Whether it actually becomes that first best approach to governance depends on whether international institutions are designed to promote experimentation by governments, firms and NGOs—and whether that experimentation is designed for learning and scaling. Using the Paris outcome

[19] Dorf and Sabel 1998; Sabel and Simon 2011; Sabel and Zeitlin 2008.
[20] De Búrca, Keohane, and Sabel 2014.

as a framework, we describe how those conditions can be met and what they imply for the future of intergovernmental bargaining and

There are to be sure large differences between the US and EU regulatory systems—where the workings of XG were first observed and then explained theoretically—and the international system where it may have its greatest promise in helping societies manage problems like climate change. Those differences include the distinctive means by which penalty defaults are created and applied internationally and the greater fragility of the structures for engaging relevant actors at the international level. Within modern polities there are extensive administrative procedures, such as "notice and comment" participation in regulatory rule making, that facilitate the gathering of information and the engagement of firms and NGOs with public authorities. Despite the emergence of analogous forms of consultation, grouped under the name of global administrative law, those structures are less elaborate and reliable at the international level.[21] This is because international governance has been dominated by intergovernmental bargaining between high-level negotiators, culminating in treaties in treaties that fix rules for signatories, and may provide for a court-like body to resolve disputes over compliance. These treaties amount to contracts between the states party; they traditionally leave little room for ongoing consultation of affected interests.

This difference in the accessibility of domestic and international regulators matters for our argument. An important insight of XG is that under uncertainty effective problem-solving can't be restricted to agreements between officials and managers at the apex of hierarchies. Real experiments and learning depends on joint exploration by all those with knowledge of potential solutions. This entails cooperation across the boundaries of public- and private-sector organizations, across levels – – from top to bottom and back – – within these organizations, and between them and civil society NGOs. We will see that the most successful international organization devoted to climate change – –the Montreal Protocol on Substances that Deplete the Ozone Layer– – already does this. An effective XG approach to international governance must be attentive to the possibilities for generalizing such examples by making existing international arrangements more hospitable to extensive collaboration, by extending the scope of sectoral XG efforts, and by "internationalizing" national XG successes.

In Chapter 2 we first explain how the world got to this position on climate change. For two decades—from 1989 when global negotiations on climate change began in the UN General Assembly through the signature of the Framework Convention on Climate Change in 1992 to the 15th Conference of the Parties to that Convention held at Copenhagen in 2009—integrated top down strategies were assumed to be plan A. In retrospect, it is striking how much evidence there was, from the beginning, that this would not be the best approach. But that evidence

[21] On global administrative law see Kingsbury, Krisch, and Stewart 2005.

was ignored, and the world spent nearly two decades on climate diplomacy—with little tangible impact on emissions—while never trying alternative models. This history helps explain how the door has opened to bottom up strategies today, but also why such strategies could be a just as ineffective as the last two decades of top-downism.

In Chapter 3 we explore how XG works in theory and illustrate from studies that have detailed XG systems in practice. We explain how decentralized governance can respond to uncertainty when integrated, monopolistic, global approaches cannot. With penalty defaults in the background, effective XG begins by setting provisional goals and authorizing actors with relevant knowledge to devise ways of meeting them. The initial goals are then revised in light of a review of the findings, and the cycle begins again.

Because the goals are avowedly provisional—more in the nature of rebuttable presumptions than unconditional obligations—they are easier to agree and revise. Moreover, practical, on-the-ground problem solving can canvass more possibilities than synoptic review by experts, not least by empowering and making visible new actors, outside the circle of incumbents, with little to gain from the status quo and much to gain from innovation. In this way collaborative investigation advances the frontier of feasibility, improving our sense of where we are going and how to get there. Advances in one sector suggest analogous solutions in related ones.

The theory and practice of XG thus helps explain how decentralized or piecemeal problem solving generates individual and collective value. By working on decomposed, practical problem solving it yields immediate value to the actors who face penalties for failure. It also contributes parts of an overall solution as well as the public good of practical regulatory knowledge. By providing this information it addresses, centrally, a cognitive and political challenge for societies that are trying to manage complex regulatory problems. It enlarges the actors' sense of what is doable and can come to be; it offers practical lines of sight for nascent interest groups that want to form to advance new regulatory solutions—whether new industries that seek competitive advantage through regulation or NGOs that seek social goods that such regulation affords.

Applying this logic to climate change, decomposition of the global problem into local problems may prove a crucial step towards improving the informational and political landscape that shapes the kinds of global agreements that will be feasible in the future. Paradoxically, whereas most attention to international climate diplomacy has focused on governments' power to set incentives as the key to stringent and effective global agreements, the way to actually achieve that outcome may well be to first use public authority to encourage decentralized cooperation among firms, trade associations, professional groups and NGOs of many kinds.

In Chapter 4 we look to recent history to explain how XG is already working to solve problems crucial to progress on climate change. XG is an unfamiliar kind of institution—built on more discussion and deliberation among the actors than is characteristic of markets, but also on critical exchanges across higher and lower levels of activity that violate the top-down principles of hierarchy. It might be dismissed as a hothouse flower, a byproduct of some particular settings in the US or the highly developed regulatory apparatus of the European Union. In Chapter 4 we show that we have already encountered institutions and regimes of this very type, most often without noticing it. We retell the history of three iconic institutions of environmental regulation: the Montreal Protocol on Substances that Deplete the Ozone Layer, which has phased out most ozone-depleting substances (ODS) globally; the California Air Resources Board (CARB), which has been on the front lines of highly successful efforts to clear the air in California and by extension in much of the United States; and the cap-and trade regime for reducing power-plant emissions of sulfur dioxide (SO_2) in the US, the world's first large-scale allowance-trading system.

In the conventional telling the Montreal Protocol stands for the idea that it is prudent and expeditious to begin consensus building with general, but easily modified framework agreements, and then proceed to target setting and program design as science brings solutions into focus. CARB stands for the idea that jurisdictions with significantly large markets and powerful regulators—in this case the California market for autos—can shape the direction of technological development and speed mitigation of environmental harms through technology-forcing standards. A "California effect" can raise environmental performance for the world because regulators wisely set strict standards that the rest of the world then sometimes wisely, but more often grudgingly follows. The SO_2 regime stands for the idea that market-based systems can induce significant technological innovation (dynamic efficiency) while optimizing the application of existing technical know how across various settings (static efficiency).

We show in Chapter 4 that the conventional telling in all these cases is incorrect. Success in all three depended crucially on bottom-up, decentralized and experimentalist governance. Institutions were less top-down and more experimental than understood.

In all three of these cases, policy-makers knew much less, ex ante, than outsiders have assumed. Success in these three cases was rooted in responses to uncertainty that encouraged exploration and createed information pooling regimes on the lines XG. Success resulted not from especially favorable conditions. Despite frequent claims to the contrary ODS did not prove easy to eliminate. California's commitment to cleaning the air most certainly did not make cost irrelevant; and the fortuitous appearance of large amounts of low sulfur coal did not guarantee success of the SO2 emission trading program. Instead, success in all these cases stemmed from careful institutional designs aimed at experimentation and active adjustment.

These three retellings of iconic histories help reveal the right lessons to be learned from prior successes. Getting that history right is particularly important in the case of the Montreal Protocol since that agreement has been the model for the first two decades of efforts to manage climate change. It is commonplace today to contrast the "easy" case of Montreal with and the "hard" case of climate change, but that was surely not the actors' view when the Protocol was crafted or extended to new classes of ODS.[22] In the early 1990s the lesson that most observers took away from the Montreal Protocol was that integrated top-down institutions would be effective. But they ignored the deeper and contrary lesson, which was that what looked like integrated top-down agreements became feasible through the Montreal Protocol only because experimentation and learning revealed how quickly ODS could be phased out, and at what cost. Just as the wrong lessons were learned from Montreal in the early 1990s, and this misunderstanding helps explain why efforts to manage climate change were put on the wrong track, so today it is equally wrong to dismiss the Montreal model as a poor inspiration for managing climate change. The right lessons are about institutionalizing the process of experimentation and learning.

In Chapters 5 and 6 we apply this logic to climate change, focusing on the ways experimentalist decomposition of the problem can be encouraged nationally and internationally. This mode of governance builds on self-interested dispositions to take action where they exist as well as strategies for constructing penalty defaults where they do not. Those motivating forces help explain the onset of XG-cooperation in climate, and wise institutional design can help achieve linking and scaling up these components into an eventual global system of regimes.

We argue that for very many internationally traded goods—whether agricultural commodities such as palm oil or sugar or industrial products ranging from cement to automobiles—the opportunities for inducing active problem solving are familiar and straightforward. Because the dominant actors in these markets are typically few, and often sensitive to the risks of reputational damage or loss of market access, they can be moved to action either by direct self interest, as a way of both avoiding the risk of regulation and entrenching their position within markets. If firms are confident that they can cut production costs more easily than competitors, self interest may lead them to establish environmentally friendly efficiency requirements. This is the case of cement, supply chains for high-value branded goods such as consumer electronics and white goods. In other circumstances an external motivating force is needed—for instance, NGOs' threats of embarrassing publicity (the case of palm oil and sugar) or the threat of trade restrictions that make access to a large market conditional on active participation in emissions reduction (the case with CARB's efforts in California or the EU's efforts to stem illegal logging). The logics are similar across cases, but the scale and organization of the key elements—the setting of provisional goals,

[22] Benedick 1991; Parson 2003.

the threat of penalty defaults, and the institutionalization of learning and scaling—varies with industry and government.

In chapter 5 we show how this logic can play out at the sectoral and nation levels, where much of the real capacity to develop provisionally and test policies is to be found. At the sectoral level we look at promising, but still fraught, efforts to reduce emissions in international maritime shipping, palm oil production, and civil aviation. A study of emissions reduction in Irish agriculture affords a close look at the kind of national policies – – and the obstacles to them – – that encourage ground-level learning yielding both more efficient and cleaner productIon. A case study of the EU's policy to limit deforestation by preventing illegal logging illustrates how large trade partners can use control of market access to induce construction of XG institutions, extending their own environmental policies across borders, but in a way that respects national diversity.

In Chapter 6 we focus on the implications for international institutions. In a system where countries and leading industries are experimenting with policy solutions, one of the central roles for international institutions is to help the most active and innovative participants learn from each other; and such mutual support would be the springboard to alliances that begin to impose obligations first on the immediate participants, then—as feasibility is demonstrated, on others. Where possible, international institutions may help organize penalty defaults, such as trade sanctions for industries and countries that fail to cooperation. Learning and collaboration would emerge in a decentralized fashion. The interim result would be a plurilateral system of coordination of international and national regimes operating loosely under the UNFCCC as an umbrella, and the prospect of incrementally extending the breadth and depth of that regime into an integrated undertaking. Exactly that system is now emerging. Many of the building blocks were created, at least in theory, under the December 2015 Paris agreement.

Using the Paris building blocks effectively requires efforts on several fronts. One is a shift in mindset that sees this new style of governance as the best strategy for managing complex, uncertain problems. This shift is needed so that XG is not just seen as an epistemic solution to climate governance but also one that can rewire the underlying political interests in ways that are more favorable to cooperation over time.

In addition to a shift in mindset—the elements of which are already present as more analysts and governments embrace the bottom-up approach agreed in Paris—new strategies are needed to create the right nuts and bolts for an experimentalist system of climate governance. Today’s world has arrived at Plan B accidentally and thus has not paid close attention to the policies and institutions needed to make it work effectively. For all the success of Paris, we

note that the list of tasks not completed in Paris—deferred until later, when no credible deadline looms—is long.[23]

In Chapter 6 we outline those policies. Particularly neglected is the need to build effective mechanisms for pledging commitments and experiments as well as effective review mechanisms so that the learning process can proceed. Attention is needed, as well, to not blocking—and ideally encouraging—countries and groups of countries to impose penalty defaults that induce cooperation.

Chapter 7 concludes by reviewing the overall argument and suggesting its broader applicability. For decades, scholars who have studied strategies for making deep cuts in emissions have emphasized the need for transformations in systems of technology and governance. Those new systems do not appear *de novo* like a big bang. They require innovation and learning. With investment and experience new ideas— technologies, business models and institutions— improve and displace outworn concepts. We offer XG as a theory that helps us understand how to institutionalize--and thereby accelerate and extend--such learning. With successful learning, bargaining problems that previously seemed insoluble become tractable. As the technologies for cutting emissions improve, costs and political concerns about impacts on economic competitiveness decline. New interest groups that favor new technologies and businesses that stand to gain from them emerge--and with them new political call coalitions in support of further change.This, fundamentally, is the dynamic that has led to some of the most successful efforts to reduce emissions. Pursued deliberately it will lead to practical solutions to the climate change problem.

In chapter 7 we note that very similar challenges are emerging in adaptation to climate impacts. Just as with emissions reductions, there is enormous potential and need for adaptation, yet little shared knowledge about which approaches will be most effective. Again as with emissions reductions, new funds are emerging to help countries adapt, yet there is no real strategy for learning how to spend those funds wisely. XG can help.

And beyond climate, more active XG strategies can help governance in other areas. For example, international institutions aimed at promoting international trade and investment need urgently to learn how to square their missions with the need to manage the adverse impacts of globalization. Institutions that coordinate regulation of finance and accounting, as well, would benefit from a more experimental approach to design—although some of them, as we suggest in chapter 7, are—like some of the most effective regimes addressing climate change—already doing that without realizing they have adopted an XG strategy.

[23] Victor 2011.

CHAPTER III. Theory of Experimentalist Governance: Solving Problems in the Context of High Uncertainty and Complexity

1. Introduction

It is getting much more difficult to foresee where technology or markets are going. This uncertainty makes planning in the traditional sense of drawing detailed blueprints for long-term action a fool's errand. In addition to higher uncertainty, civil society, the state, industrial organization and technology are also becoming more complex. More—and more heterogeneous—private and public actors, domestic and foreign, have to coordinate with and learn from each other to design and deliver products and services while ensuring their safety, protecting the environment, and providing safe and decent conditions of work.

Though climate change is in some ways a uniquely global problem it is, as we saw, also, and fundamentally bedeviled by just these same two general conditions of uncertainty and complexity. Most emissions result from energy systems built on long supply chains using constantly shifting suites of technology. Deep decarbonization will heighten the uncertainty and complexity of these supply chains in ways that defy prediction. The upshot is that rapid decarbonization depends on the capacity to indentify andadjust to emerging possibility, not to anticipate it..

Experimentalist governance (XG) explains how firms, public authorities and civil society institutionalize the coordination and learning that complexity makes necessary without attempting the kind of planning that uncertainty makes impossible. In this chapter we explain the central ideas of XG; in the next we show that institutions reflecting XG principles of construction are at the heart of a number of the most successful responses to climate change.

To set the context, we first review the response of firms and regulators to the rise of uncertainty and complexity and how those responses make collaboration within industries and between firms and government more necessary and more possible.

Next we generalize these responses to explain the architecture of XG, an institutionalized process for parallel exploration of possible solutions. It begins with setting provisional, framework goals and revises both means and ends through rigorous evaluation of experience. Each step in this process—the setting of provisional end goals, parallel searches and revision in light of experience—has distinctive features that together distinguish XG from familiar forms of centralized, top-down forms of organization based on formal rules and explicit knowledge, like bureaucracies, and de-centralized, bottom-up forms of organization based largely on tacit understanding, like markets.

We then examine the incentives for firms to participate. To encourage cooperation, without discouraging the information sharing on which joint learning depends, XG institutions have developed a distinctive kind of incentive: the penalty default. This incentive centers on a threat that persistently uncooperative behavior will be met with a draconian sanction, such as exclusion from a valuable market. This threat greatly reduces the chances that veto players exercise their power to hold others hostage to the status quo. It also encourages capable actors to participate in the search for ways to meet demanding goals because it opens new markets and offers new types of industrial organization where firms that are first movers can thrive.

Penalty defaults are more lenient and forgiving than conventional regulatory sanctions in that they generally do not punish good faith failure to meet requirements; however, they can also be much harsher, because of their draconian response to deliberate obstruction and incorrigible incapacity to improve. Penalty defaults, we will see, can be imposed in diverse ways—formally by law; by moral pressure mobilized by civil society organizations; and by the economic and political power of dominant actors. As no domain is beyond the reach of law, morality or power, penalty defaults are potentially available when needed. But of course to realize this potential and actually establish the sanctions in particular cases requires a political fight.

Finally we look at at the affinities between XG and earlier theories of decision-making under uncertainty and complexity—such as the enthusiasm amongst regulatory reformers for greater use of market-based incentives and performance-based regulation. XG shares with them a deep respect for the limits of individual and collective foresight and therefore their insistence on the need to find the way to profound transformations through incremental exploration. But XG departs from these earlier views in holding that, under conditions of heightened uncertainty, this exploration requires explicit deliberation among stakeholders regarding the choices of means and ends; and deliberation creates possibilities for formal learning and democratic accountability that the earlier views denied.

2. Uncertainty and complexity

In a stable world, where markets grow steadily, products and services change slowly and the direction of technological development is clear. Firms have strong incentives to maintain reliable control of suppliers of key inputs through ownership or reliable contracts. This vertical integration allows the firm to optimize the design and production of parts and components to each other, and to protect itself against disruptions of supply, especially by opportunistic partners tempted to withhold key deliveries of specialized goods unavailable on the market unless contracts are renegotiated in their favor.

As markets have become more heterogeneous and the trajectory of technological development more uncertain, mass producers of goods and

services that could become quickly obsolete have needed to become much more nimble. The widely observed result in industrial organization is vertical dis-integration. Firms have decomposed production into tasks—the production of components or sub-systems, assembly of the final product—accomplished by independent companies, collaborating with many different clients and linked to particular end producers in supply chains.

Vertical disintegration goes hand in hand with the reorganization of production and design. Traditional mass producers sought to reduce errors downstream in the implementation of designs through exhaustive upstream planning: given enough time, and relatively stable technologies and practices, all potential flaws could be identified and eliminated. The increasing pace of innovation, greater uncertainty about the trajectory of technological change, and the complex, emergent properties of rapidly shifting production and marketing systems changed that. Planning gave way to co-design and constant adaptation. Firms began to collaborate with key suppliers at the outset of new designs—using each round of consultation to winnow alternatives, and as the starting point for elaborating more refined proposals in the next.

Changes in design and production also affected how firms managed risk. In the old mass production model, firms hedged against breakdowns in operations by holding large buffer stocks of work-in-progress inventory. Uncertainty dramatically increased the cost of these hedges. Firms responded by eliminating the buffers—at the limit producing one piece at a time. Just-in-time or lean production means breakdowns stop operations; production can only resume when the disruption has been traced to its source and corrected. Where the mass production firm concealed breakdowns through inventory hedges, the firm facing uncertainty makes production *more* vulnerable to disruption--obligating itself to learn rapidly from mistakes, and eventually reducing the incidence of breakdowns to previously unimaginable levels.

Thus in both design and production successful firms responded to increased uncertainty and complexity by openly recognizing the provisionality of their initial approaches, and focusing on rapid improvement through quick detection of incompatibilities and errors. Learning cycles shortened. In making these changes within reconfigurable supply chains and contracts, we will see, firms equip themselves in the normal course of business with both the flexibility to shift technologies and the kind of exacting information on the minute to minute flows of goods and information on which emissions reductions and other responses to climate change depend.

The vertical disintegration and short learning cycles that are characteristic of modern manufacturing are also coming to characterize modern agriculture, sylviculture, mining, and refining of raw energy into useful forms such as fuels and electricity—essentially all the sectors of the economy implicated in the effort to mitigate global emissions. Developments are perhaps most salient in

agriculture, especially in the vertiginous diffusion of precision or no-till planting. As its alternative name indicates, precision agriculture does away with plowing. Seeds are inserted (through the biomass remainder of the previous crop) essentially one at time, to a depth and with a dosage of fertilizer adjusted to the conditions of each "pixel" of land. This avoids soil compacting, decreasing erosion and increasing yields; results are monitored pixel by pixel, and conditions are adjusted after each planting to take account of micro-field variations in drainage or soil. Precision agriculture induces demand for continuous improvement and differentiation of inputs, spurring, for instance, the emergence of sophisticated biotech firms adapting seeds to local contexts, and of specialist producers of no-till seeders and sprayers, for targeted, low-dose application of pesticides and herbicides. We will return to these developments in case studies of reform of forestry in Peru and dairy farming in Ireland in Chapter 5.

Similar changes are afoot on every other major aspect of the economy implicated by mitigation of emissions. In silviculture a shift is far under way toward active management of trees like crops, with all the opportunities (albeit with lower rent generation) evident in the shift to modern precision agriculture. Management of forest lands, as well, is aided by the rise of sensor technologies that allow monitoring and management from a distance. And in energy, the IT revolution is transforming markets and making them much more nimble—yet harder to predict. Most notable is the shift in electric power away from stable baseload generating plants (often fueled with coal purchased under long-term contracts) and toward a grid that includes much larger volumes of variable and unpredictable renewable power. Decentralization of the grid toward more local control—such as rooftop solar panels and local microgrids—is further adding to complexity and unpredictability of grid operations. What happens in the grid is vital to decarbonization since almost every study finds that big reductions in emissions will shift energy systems away from consumption of raw energy sources such as coal, gas and oil and toward electrification. In sum, firms across the economy are coming to have the flexibility in choosing new technologies and the capacity to continuously monitor and optimize their performance that decarbonization of production demands.

These changes in production methods have had profound effects as well on the regulation of market actors. In the old, more stable world in which regulated entities within particular domains were relatively homogenous, it was possible in principle to write enduring, generally applicable rules. The chief obstacle to doing so is that while private actors—the addressees of regulation—have a clear understanding of the potential effects of regulation on profits and choice of technology, the regulator does not. In that old, stable world firms have had strong incentives to exploit this information asymmetry to escape costly requirements and to manipulate regulation to favor incumbents over new entrants. The regulator’s task under these conditions has therefore been to elicit from firms the information needed to protect the public, without being “captured” or ceding

control to the better-informed, regulated party.

The regulator faces different problems under new world conditions of ubiquitous complexity and uncertainty. As the addressees of regulation become more heterogenous (even idiosyncratic) in their choices of technology and behavior, it has beome much more difficult to write general rules; and such rules as can be written will soon need to be revised to account for further differentiation. Under pervasive system-wide uncertainty, moreover, neither the regulator nor the regulated firms can hope through accumulated experience to anticipate all potential hazards. The pace of innovation is too rapid to allow thorough testing; and the subtle problems of communication among independent firms in complex supply chains further increase the likelihood that rapid co-development of innovative products and services introduces latent hazards. The information asymmetry between regulator and regulated entity still exists, of course, but it is dwarfed by the much bigger problem that both players face: shared ignorance. As both realize this—and realize the risks of the other acting alone—incentives to pool information rise. Neither the regulator nor the regulated entity can anticipate the full range of hazards and opportunities that rapid, collaborative shifts in industrial organization create—nor the hazards and opportunities from mis-steps in attempting to regulate that system.

The nature of regulation is changing accordingly. In response to increasing heterogeneity and unpredictability there has been a shift from design-based regulation, in which the regulator specifies the type of equipment to be installed, to performance-based or functional regulation, in which the regulator specifies the required outcome and leaves it to the regulated entity to choose or devise the means of complying best suited to its context. In practice the regulator obligates firms to systematically canvas their operations and demonstrate how they mitigate known hazards. Essentially every modern industrial society has, to varying degrees, gone through this shift toward a greater role of performance-based regulation. Indeed, regulatory reform in nearly all the emerging economies is aiming at similar outcomes.

But given the uncertainty all such ex ante precautions--whether cast in the old mold of design-based rules or the newer one of performance-based regulation--this process will be fallible. In recognition of this fallibility, the regulator extends ex ante or pre-market review to continuing, ex post or post-approval surveillance of products admitted to the market. Practically the regulatory task in this new world of high uncertainty and complexity is to organize and supervise joint investigation by firms of emergent risks and responses that avert harm. This requires institutionalization of incident or event reporting procedures: systems to register failures and anomalies in products or production processes that could be precursors to worse outcomes. This institutional helps reveal information that regulated and regulator, alike, seek about safety and performance that the market would not automatically internalize into production processes and traditional regulatory processes would not automatically uncover. This

institutionalization helps to trace out and correct root causes of failure, alert others in similar situations when there is a potential unknowable hazard, and raise the odds that what is learned in a particular product generation and process is integrated into the design requirements for the next generation of implicated components or installations.

Together the responses to heterogeneity—and thus uncertainty and complexitsy—has been to transform the regulator's role. Instead of writing general rules directly, the regulator's task is to ensure that regulated entities establish and update systems for identifying and mitigating particular risks that no central rule-maker could possibly hope to discern. The regulator becomes a meta-regulator, obligating the primary actors to establish regulatory regimes tailored to their particular circumstances; verifying the effectiveness of these regimes; and coordinating through oversight of incident reporting systems efforts to improve current measures by learning from their shortcomings. The firm and the regulator, alike, shift from optimizing within a known space of technologies and preferences to jointly managing uncertainty.

Uncertainty and the overall reorganization of production change the relation of the meta-regulator to regulated entities, and of the latter to each other in ways that encourage and enable such recursive meta-regulation. First by reducing information asymmetries, uncertainty diminishes firms' and other regulated entities' strategic advantage over the regulator and increases the returns to both of cooperative hazard avoidance. In classic theories of regulation, information asymmetries decrease as the regulator becomes knowledgeable about the technology and industry. But the logic here is the opposite—information asymmetries decrease because the firm becomes less knowledgable--lessable to predict and control--its environment. Second, and similarly, under uncertainty firms linked in supply chains and industries have common interests in avoiding disasters that taint the reputation of all; and from this concern follows a shared interest in learning from others' experiences before encountering problems on their own (Gunningham et al, 2004). Third, since mastery of continuous monitoring and short learning cycles is a prerequisite for participation in supply chains throughout the economy, firms will already have for their own reasons developed the capacity to respond to the new regulatory demands for close and continuous monitoring of successful mitigation of known hazards, and for reporting incidents that could indicate latent ones. Regulation, building on and developing these capacities, reduces risks in the supply chain as a whole that firms, acting alone, cannot.

But even under uncertainty firms and regulators do uniformly have incentives to collaborate closely. Some firms of course will have little or no interest in joint risk mitigation. Large, capable companies may prefer building risk mitigation systems internally, and with key suppliers, rather than collaboration with less able and reliable partners, with the attendant risk of exposing proprietary techniques to competitors. These internal or closed systems are in many respects quite

analogous to cooperative regulation—they have independent review boards and oversight, monitors, and extensive public reporting.

Yet other actors may directly oppose or attempt to undermine joint regulation. Generally, less capable actors may prefer to protest new regulatory requirements that might overtax them. Lobbying organization ranging from trade associations to mayors' conferences group members along the whole continuum of capacity, and so will be pressured by some to help organize effective responses to the new requirements, but by others to oppose them (Gamper-Rabindran and Finger 2013; Finger and Gamper-Rabindran 2012). This split in organized industry groups can lead to outcomes that are unsupportive or even hostile to joint regulation. And some firms may oppose any outcome that increases the regulatory burden when they see no alternatives to their current product lines and production methods. Similarly, some regulators may not embrace this new mode of engagement if they fear their own capacity to understand these industries, question their legal authority to shift away from traditional modes of regulation, or face other administrative and political roadblocks.

We return to the problem of holdouts and coalitions for the status quo when we take up the penalty default below. These qualifications shape regulatory outcomes in particular cases, but they do not change the direction of development: increasing uncertainty and complexity decreases the information asymmetry in favor of the regulated entity and generates a recognition of shared ignorance in the face of latent hazards, together with the disposition, at least on the part of some, to cooperate in exploring possibilities for mitigation.

3. The Architecture and Operation of XG

Starting with these prototypical cases of the firm and the regulator facing uncertainty and complexity we can easily generalize to the architecture of XG institutions and the process by which they operate. The constituents are a “center” and a set of “local units.” The center is a repository and manager of general knowledge. It has authority for convening stakeholders to set and revise goals, and often the authority to impose sanctions in the form of penalty defaults as well. The local units have primary responsibility for doing the work of problem solving in the context of real-world local conditions, and bringing their experience of success and failure to bear on the interpretation and re-elaboration of goals and methods. The local units, in a well-functioning XG system, are the sites where general knowledge is tested against particular conditions.

This topology of center and units can be observed in many different domains of a successful XG system. The center might, for instance, be a large firm, and the local units the first-tier supplies with whom it collaborates in product design. Or the center could be a government agency, and the local units the private actors it regulates or the public or private service providers with which it contracts.

These relations are often nested. A first-tier supplier will be a local unit of its large-firm customer; but it will be the center for the local units of its own first-tier suppliers. A State environmental protection agency is at once a local unit, responsible for fixing state implementation plans to meet clean air and clean water requirements under the jurisdiction of the national environmental authority; but it is also the center with regard to local units of the state's air- and watersheds, each responsible in turn for elaborating its respective part of the eventual state-wide plan. But such nesting changes nothing in the relation between contiguous "higher" and "lower" units, which remains the same regardless of the units' location in the overall system. Together, the center and local units set and revise goals, and the means of pursuing them, in an iterative process that proceeds in four basic steps.

First, framework goals (such as a target reduction in emissions levels or a requirement to achieve "good water status") and provisional measures for gauging progress toward them are established. Whether the goals are fixed by legislation, administrative action, a governing board of directors, or court order, they are arrived at through consultation among the center and local units and relevant outside stakeholders. On international environmental matters, many of the most encompassing goals come from the international process itself—the widely discussed goal of stopping warming at 2 degrees emerged largely from political deliberations in Europe, was partially enshrined in the G8 (now the G7), then repeated in many other settings from the World Economic Forum to major NGO initiatives. It has reverberated globally and is now widely seen in local planning processes down to the city and community level.

Second, local units are explicitly given broad discretion to pursue these ends as they see fit. But, as a condition of this autonomy, the local units must, third, report regularly on their performance and compare their results with those obtained by other local units employing different means to the same general ends. These peer reviews require the local units to explain their efforts to each other and the center; to show why they favor their approach over plausible alternatives; and to demonstrate progress by some jointly acknowledged measure of success, or to propose adjustments if they are not progressing. The center provides services and incentives that facilitate this disciplined comparison of local performances and mutual learning among local units. Fourth and finally, the framework goals, performance measures, and decision-making procedures themselves are periodically revised in light of the findings of the peer reviews, and the cycle repeats. We briefly consider each of these steps.

Setting Goals

XG, and the open-ended goals that are characteristic of it, emerge when public and private actors agree that a certain problem is urgent, yet familiar problem-solving strategies — delegation to experts or reliance on markets — have failed or

are unlikely to provide a solution. Urgency makes inaction unacceptable; yet the shortcomings of the usual problem-solving strategies make it impossible to fix on a detailed plan of attack with precise goals. Collaborative exploration is therefore preferable to inaction, at least for a core group of particpants. But given the uncertainties of the situation the goals of this collaborative investigation are necessarily open ended ("good water quality") or aspirational ("reduce emissions by 50% by 2020"), with the understanding that more precise targets will emerge in the course of problem solving. Such goals are all the easier to agree because the actors know that they are open to interpretation from the outset, and subject to periodic and explicit revision.

The advocates of this initial agreement on goals, and the parties to the institutional arrangements it creates include at a minimum key public and semipublic actors (such as standard setters) with the legal or de facto authority to set binding requirements. This process of setting goals also includes civil society actors—firms and their trade associations, NGOs of various kinds—with "local" knowledge of the problem and at least inchoate ideas about solutions or where to look for them. Depending on the political system, the expanse of these civil society actors could be very large. Without the authority of the public and semipublic actors, the private actors may be impotent; without the practical knowledge of the problem, based on continuing, immediate experience—knowledge not yet captured in consolidated theory or reflected in prices—the authorities are blind. One of the many implications of this process is that the bright line between "public" and "private" actors will begin to blur.

There is a substantial risk that the coalition in favor of the framework goals excludes actors--lesser-known or less powerful--whose understanding of the situation and urgent stakes in the outcome give them as good a right any party to the agreement to voice their views. But the roster of participants, like the goals themselves, is provisional and open to correction. As the process of searching for solutions—a topic we address in the next section—deepends and expands its scope it often enlarges the circle of participants. It is a search for surprises--for ideas and points of view overlooked or excluded at the outset—and thus may implicate new industries, regulators and other actors. This open-ended and comtestable process will still fall short of the ideal of full and fair representation of all affected interests; but it is likely to come much closer to that deliberative ideal than convention forms of standard setting and public rulemaking, open de facto or de jure only to well-established or well-equipped interests.

Searching

Once goals are set the local actors begin searching for solutions in the ways shaped by the particulars of their context as well their varying experiences and capacities. Under uncertainty the resulting parallel or concurrent searches have enormous advantages over the examination of a series of alternatives one by one, as might be undertaken by a single actor with pretensions to knowing all that is (or

should be) known. The more uncertain the situation the harder it is to know with confidence the most promising place to start. Concurrent searching herefore starts investigation in many, different places at once, instead of vainly trying to rank approaches from most to least promising to determine an order of attack. This decreases the chances of getting stuck in dead ends, increases the chances of discovering hidden passages to solutions; and—because the searches are simultaneous—accelerates learning.

From the standpoint of design in the age of mass production the advantages of broadening search in this way come at the unacceptably high price of decreasing its rigor. The key assumption of traditional design was that only proceeding step by cautious step from general conception to blueprint assured a reliable outcome. From this vantage point designers canvassing many alternatives at once forego the possibility of evaluating any of them thoroughly, producing results that are suggestively informative but dangerously error-prone. That reality and assumption created strong lock-in effects for incumbents and probably redirected technological change within existing paradigms (where predictability is high and risks to incumbent firms and regulators are low).

Experience of parallel search under uncertainty teaches otherwise. Because they address a common problem, but from different starting points, alternative approaches pursued in parallel are mutually illuminating, with the strengths of each revealing the weaknesses of the others. Instead of a trade off between searching broadly and searching reliably or rigorously, the repeated finding is that the two are complements: Each search is more likely to be effective because it is guided in part by the learning of the others, and the ultimate outcome to be reliable because it is informed by the learnings from all. And because the contours of the search are contestible it is easier for new ideas—including technological paradigms—to enter. This reality is playing out today in the electric power industry, for example, where some regulators have created new decentralized visions for electric power service. Technology suppliers and other new vendors have invested into those margins and led to further expansion and shifts in the scope of traditional regulation.

Broadening search naturally broadens participation beyond the parties to the framework agreement. The aim of joint search is to find novel solutions that promise more than the familiar ones; and those solutions will be embodied in persons, firms and groups un- or little known to convening members of the XG coalition. Vertical disintegration greatly facilitates the discovery of the relevant innovators: Through the 1970s and 80s research on emissions-reduction technologies, for example, was hidden deep in the bowels of very large corporations; today, as we will see, the suppliers of such technology are likely to be independent firms, competing with each for customers in various industries, and for influence with regulators and standard-setting bodies generally. Such innovative suppliers are looking to be found, so searches for them will likely be more successful. The increasing heterogeneity of civil society works to the same

effect: the profusion of civil society groups from the local to the international level both protesting and (perhaps with greater frequency) actively engaged in trying to solve problems related to climate change means that here too the search for relevant, and in many cases ultimately indispensable interlocutors, will enlarge the circle of deliberation. In both cases extending participation in the search beyond the initial incumbents reinforces the coalition in favor of reform by introducing actors with little attachment to the status quo and pronounced short- and long-term interests in innovation and substantial change.

The scope of collaborative investigation will likewise tend to increase as problem-solving proceeds. Initially the participants will focus on problems too large for any individual actor to solve (or the capable ones would do so, and spare themselves the burdens of cooperation), but not so big that the participants together cannot expect to appreciable results with measurable benefits to each (or again there would be no individual motive for joint action): reducing emissions in a plant or company would plainly be too small a project; reducing emissions in the US too large; and reducing emissions in a particular industry, like maritime shipping or cement production, or in a municipality or state would plainly be in the Goldilocks zone of "just right." But solutions to problems in one domain will often prove applicable to others; or solutions will be discovered to pose novel, follow-on problems of their own. Experience under the Montreal Protocol provides conspicuous examples of both. Either way the scope of problem solving increases, bringing new actors into the search and setting the stage for revision of goals

Peer Review

Collaborative search is regularly punctuated and redirected by peer review of interim results. Peer review--review of the performance of a local unit by (representatives of) the other local units and the center--serves two intertwined functions. The first is to provide a regular, routine occasion for learning from the different approaches to the framework goals by reaping the rewards of cognitive diversity. Both in explaining its own successes and failures and reacting to the performance of its peers each local unit makes explicit its assumptions, experience and expectations, and elicits the explications of others. Clear failures—approaches that are demonstrably inferior to alternatives pursued in comparable local units—are eliminated early; promising successes—that perform well on current metrics and show signs of some generalizability—are established, where relevant, as potential benchmarks. Where metrics seem inadequate or misleading questions are raised for further discussion; and the same applies, though presumably less frequently, to the possibility of revising goals.

The second function of peer review is to alert participants, and especially the central unit, that particular local projects are foundering, as reflected in poor performance on the agreed metrics. Often it will be unclear whether the difficulties are rooted in approach or in its implementation, and if the latter, where the

shortcomings lie. The poor showing on the metrics—like the break-down in production in a modern factory, or an anomaly in operations that leads to an incident report to a regulator—is designed to trigger a review of the root causes of the problem, and with it a search for corrective actions or a revised approach. Because the aim of this monitoring is to encourage learning and capacity building we will call it diagnostic, to distinguish it from conventional systems of monitoring that aim to induce improvement by incentives—rewarding good performance on metrics and sanctioning—rather than by deliberation and joint problem solving.

Peer review is the element of XG that most directly confounds the distinction between top-down organization, in the sense of bureaucracies, and bottom-up organization, in the sense of markets. In peer review the general knowledge embodied in framework goals established at the "top" or center of an XG regime is questioned and revised in light of differing local applications. The new understanding becomes the starting point for subsequent rounds of appraisal and revision. Neither level is presumed to generate uniquely reliable and authoritative knowledge; rather, understandings arising at each create a vantage point from which to criticize and improve what has been learned at the other. XG itself is neither top-down nor bottom up because it works in both modes simultaneously. Invoking the philosophy of American pragmatism, we call this form of governance *experimentalist* precisely to underscore the way it uses the impact of problems—at all scales of activity, from local to encompassing—to reveal shortcomings of habits and rule-bound routines, and to prompt search for alternatives.

The process or evaluation and offering reasons for actions, which lies at the heart of peer review, also plausibly makes XG politically accountable to oversight bodies—legislatures, legislative committees, and ultimately to the public as a whole. XG regimes, born of uncertainty, have open-ended mandates, in the form of framework goals whose realization invite varying local interpretations; indeed, as just noted, in settings where there is no right starting point for search, investigation is unlikely to go far without differences in where to begin. But the more explicit the authorization of local discretion, the more the parties to the initial agreement have reason to fear that the actors will respond to the partial interests of engaged groups or the preferences of a technical elite, not the founding purposes of the regime. In this sense, the broader public and unorganized groups observing this process will fear that the problems of regulatory capture will become even worse. Instead, the deliberative nature of the process will help assure that the means chosen do serve the agreed ends—and deviations from those goals are anchored in solid, participatory reasoning.

Peer review obligates the ground-level, local actors and those at the center of the regime to legitimate themselves in just this way. Local interpretations of framework goals naturally embody not just different technical choices but also distinct values, for example different ways of balancing protection of the many constituents of a complex ecosystem against protection of the livelihoods of the

many groups in a community. By obligating each locale to explain precisely how its approach advances the common purpose better than alternatives preferred by others, and by presenting evidence of its continuing promise, peer review clarifies (and makes transparent for outside oversight) the political and economic implications of reforms that are refined within the local terrain of workable solutions.

Measured against the ideal of full and fair engagement with the views of all stakeholders at every stage of decision making, this form of accountability will, like the process for convening participants, fall short. But measured against conventional practice accountability in XG is superior. Conventional administrative rule making procedures, such as notice and comment in the US, focus almost exclusively on ex ante review. Once the initial rules are fixed, agencies typically have broad discretion to modify them by issuing guidelines and interpretations. XG--because it assumes initial uncertainty – gives equal weight to ex poste, continuing, and publically accesible review of framework goals. In constraint to traditional procedure it requires especially rigorous reason giving just when growing awareness of possibilities and problems reveals unexpected choices and makes oversight more critical and more reliably informed .

4. The Penalty Default

Prudence in the face of latent hazards, or the prospect of profiting from limiting emissions or improving safety will convince some actors to collaborate in joint investigations. But rarely will all fall into line. Some, often many, will prefer the status quo; and among those who do, at least a few will often be in a position to block any joint response by others.

The participation of actors in veto positions—and others wavering in their commitment—can be induced by the threat of a penalty default—closure of a market by denial of a license, certificate of conformity with standards or regulations, or other draconian (*in terrorem,* the lawyers say) punishment that so limits their freedom of action that they are likely to prefer working towards a feasible alternative, however uncertain initially, that reflects their preferences and sense of possibilities. Penalty defaults sanction the failure of capable actors to make good faith efforts to achieve demanding results, and persistent failure of incompetent ones to make any progress at all towards goals, once they have been set. But penalty defaults do *not* sanction failure to meet targets whose feasibility was unknowable at the outset, or good-faith efforts of laggards with prospects of improving. To discourage obstruction and protect the public and capable actors against incompetence, while encouraging cooperation and, where necessary capacity building, penalty defaults combine an unconventional penalty with an unconventional default.

The aim of conventional penalties is to deter informed, calculating actors from violating clear rules. Under these conditions the penalty is set high enough so

that the costs of violation (discounted by the probability of detection) just outweigh the gains from breaking the rule. But under the conditions of high uncertainty and complexity, these assumptions often do not hold. The rules themselves will be, to begin with, inchoate and open to question. Within an existing, shifting rule set it is not possible to send reliable fine-tuned signals to firms or regulators. Even when the goals are more settled, failure by individual actors to achieve them often results from incapacity, not calculation of costs and benefits. In place of a menu of differentiated penalties calibrated to make departures from well understood rules cost more than they are worth, the penalty default therefore substitutes a binary choice that acknowledges the uncertainty of the situation: Cooperate in a good faith effort to establish what goals are indeed feasible. When necessary to acquire the capacity needed to achieve them. Explain failures through peer review, and participate in revision of the goals. Such engagement radically reduces the risk of punitive action. Failure to engage requires accepting an unacceptable outcome.

Sanctions with these features are atypical defaults. Conventionally, legal theorists and practitioners have argued that the default is the rule that applies when the parties to an agreement have inadvertently, or by design, made no provision of their own for certain circumstances. In such cases the judge applies or devises the rule that maximizes the joint welfare of the parties, on the assumption that this is what they would have done had they attended to the matter. But of course under uncertainty neither the parties nor the judge or regulator knows what rule to apply. Instead of imposing a solution, therefore, the authorities' default response is to threaten a penalty for inaction so severe that it creates enormous incentives for the parties to collaborate in determing what the solution--the missing rule--should be. To see how the penalty default works in practice, consider how it is applied, or not, first at the inception of an XG regime and then once the regime is up and running.

In the first case the key actors are highly capable, but the trajectory of rules—the minimum standards five years and ten years from now—is unclear and open to question. Firms know easily enough how to meet current requirements, and also enough to see technological and design possibilities for meeting more stringent ones. But the actors do not, individually at least, know whether the possibilities for improved performance they anticipate will prove feasible, cost-effective—and competitive with the improvement strategies of their peers. Hence, even in the absence of collusion, and despite their appreciation of the possibilities of superior performance on one or another regulatory dimension, each actor is likely to prefer the status quo to suggesting more stringent standards to the regulator that it may not be able to meet-or that might encourage competitors to suggest targets that are even more demanding. In this sense the actors in this constellation can be thought of as caught, in their microcosm, in the same kind of logjam that blocks the nations of the world from advancing coordinated plans for addressing climate change.

Penalty defaults, in combination with corrigible, XG rule making, can unblock such local logjams, making it easier, in climate change, to unblock the global one. First the regulator announces that she will set a demanding, technology-forcing standard—well beyond current performance levels—after extensive consultation with all relevant actors. She announces as well that failure to comply with the eventual rule will result in exclusion from the market—the draconian tail of the penalty default--but that the rule itself will be under continuous review, and that demonstrably infeasible rules will be revised.

This combination of a commitment to stringent rule making, the threat of a penalty default, and the promise of continuous consultation from the inception of the rule through its application shifts the preferences of important actors. It creates an incentive for them (or at least some of them) to engage in broad exploration of possibilities. Given the regulator's commitment to act, inertia no longer favors the status quo. Since a rule is coming, the actors with the most confidence in their improvement strategies consult with the regulator in an effort to have their preferences incorporated into the rule, minimizing their own costs of adjustment and raising the costs to competitors with different approaches. Given vertical disintegration, specialist suppliers of the sought – after solutions will be among the most prompt and persistent volunteers. Even in the improbable case that no one comes forward before the rule is set, the draconian penalty for non-compliance creates incentives for relatively self-confident actors to propose favored solutions after one has been established, to correct what they may well see as infeasible requirements. Either way, the prospect that at least one actor will cooperate with the regulator induces others to cooperate as well, both the ensure that their own favored solutions get a hearing and to learn, through cooperation in the various review groups that the regulator establishes, what competitors are up to. The upshot of this broad participation is that, as the earlier discussion of regulation under uncertainty suggests, the regulator's decision is informed by good estimates of near and medium-term possibilities, and corrected as efforts at implementation warrant: Rules and revisions result from joint learning among actors, none of whom could devise a solution alone. We will see that this is precisely how ever more demanding emissions standards have been set under the Montreal Protocol and by CARB

When the regime is up and running, the constellation of rules and capacities is the reverse of the first. The rules, open at the beginning, have more resolution; there are now some minimal, and relatively fixed requirements. The sector's leaders can meet these requirements easily. But laggards, who will likely have kept to the sidelines as standards were set, may have trouble implementing, perhaps even fully understanding, the adjustments needed. Penalizing them severely—or even at all— for violations, as though rule breaking was calculating and intentional, saps resources when they are especially needed for reform. Just as perversely it drives actors who failed to meet their obligations out of ignorance or incapacity to begin deliberately concealing their shortcomings from the

authorities--curdling whatever good faith intentions they had with guile. The more effective regulatory response under these circumstances is to treat initial violations as presumptive evidence of incapacity and to provide training, extension services and other forms of support to weaker actors so they can learn to meet requirements. By the same token there are no penalties for reporting breaches of rules—indeed timely reporting usually mitigates any eventual liability. A further, complementary response is to adjust rules so that distinct and less well-resourced groups of actors—the most common examples are small firms and farms—can meet the necessary standards by procedures suited to their situation, and often in stages, over longer time periods than those set for compliance by more resourceful competitors.

But this forbearance and support has limits. Truly incorrigible actors—those that persistently failure to learn or demonstrate that they have no intention of doing do—are eventually subject to the full penalty default: exclusion from the regulatory regime and the associated market by denial of a necessary permit, conformance certificate, or quality mark. Penalty defaults are forgiving, until they are not.

The Sources of Penalty Defaults

Isolated, culturally homogeneous communities frequently order themselves to avoid tragedies of the commons and other collective-action problems--perhaps because isolation forces them to respond to the cumulative effects of individual self seeking, perhaps because shared cultural norms afford some recourse against persistent opportunism. Few communities today are isolated and homogeneous enough to be self-correcting this way; even if communities were by nature still apt to check collectively self destructive behavior, they would be too small to detect and respond to climate change, which, like many environmental externalities is cognizable only at global scale. Nor, as the preceding discussion suggests, does individual self interest supply an effective self-corrective motive when community pressure does not. For every actor that stands to gain from advancing the collective interest we can safely assume there is another--often in a veto position--who stands to lose.

For these reasons XG rarely if ever gets very far unless there is the possibly of invoking a penalty default to sanction belligerent non-cooperation and incorrigible incompetence. (There must be cases where industries in particular countries voluntarily stop polluting, but we have yet to find them.) The range of XG is therefore limited by the range of circumstances in which penalty defaults can likely be imposed.

How binding is this constraint? At a very general level, not very. Penalty defaults have diverse sources. They can be imposed by law, by moral pressure, or by the unilateral exercise of moral power. Few, if any domains, are beyond the reach of

all three. This means that, in principle at least, there is the potential to generate penalty defaults when they are needed.

Consider first the imposition of penalty defaults by normative pressure. The exact mechanism by which this moral force is exerted is unclear. Consumers in experimental situations are little inclined to pay a premium for "ethically" produced goods—"sweat free" t-shirts made under certifiably high labor standards. But the same kind of consumers will often boycott firms caught flagrantly violating environmental or labor norms. International brands with a reputation for respecting these norms are of course particularly vulnerable to such reaction; knowing this international NGOS have become extremely adept at calling attention to corporate breaches of widely shared moral convictions. Nor is the threat of moral sanctions limited to large firms. Smaller companies in local communities, operating under a "social license" dependent on continuing acceptance of their behavior—pulp mills in isolated forest settings, for example—are also exposed to moral pressure, all the more easily generated and effectively applied by neighbors and employees intimately familiar with the company practices. In any case the countless, successful campaigns--local, national and international--by NGOs to hold companies accountable for their environmental actions clearly demonstrate that normative concerns generate penalty defaults across a wide range of settings.

A second source of penalty defaults is law. The Endangered Species Act is one U.S. example. Others are contained in the Clean Water and Clean Air Acts. . Under the Clean Water Act the Environmental Protection Agency can stop development surrounding a body of water if the inflow of pollutants exceeds a total maximum daily load (TMDL). Under the Clean Air Act, the EPA can block development plans in urban areas that persistently fail to meet standards—a penalty so onerous that it never fully been applied, yet is credible enough to force even the most reluctant cities to act.[24] Development can only proceed if affected parties establish a mitigation plan acceptable to the regulator. In both cases the ground-level actors elaborate the actual solution, but are induced to do so only by the certainty that they will lose their autonomy if they do not.

The third source of penalty defaults are asymmetries of power and economic position. These asymmetries frequently make it in the interest of the most powerful and capable actors to impose standards, rules or codes of conduct on themselves and on weaker ones alike so that customers, citizens or the world can see the difference between them and reward the well-intentioned and high peforming. Private phytosanitary and other quality standards (such as GlobalGAP) imposed by wholesalers or large retailers on producers of meat, leafy greens or vegetables connected to global supply chains are one a

[24] U.S. Congress 1963, Section 7413(a)(5).

commercial example. The “California effect” associated with CARB and the corresponding “Brussels effect” of the EU—both making market access contingent on compliance with “domestic” environmental regulation—illustrate the use of economic, and political power together with legal authority to set regulatory standards for outsiders, indeed for the world. The US used such asymmetry to protect dolphins (ensnared as the by-catch of tuna fishing the eastern tropical Pacific) under the Marine Mammal Protection Act, initially by requiring countries exporting to the US to adopt the same protective measures used by the US fleet. The US again used its asymmetric advantage to ensure adoption of the Montreal Protocol.

These distinctions are, to repeat, analytic. In practice penalty defaults can often arise from several sources in conjunction, as in the case of California and Brussels effects, which are based on both legal authority and market power, or from different sources in sequence. Moral pressure can lead a large firm by itself, or together with other producers and stakeholders in a roundtable, to establish a code of conduct including environmental and labor standards binding on the whole supply chain. Public authorities can then make compliance with (some of) the provisions of the code a condition of access to the domestic market, thereby obligating foreign producers as well; and changes in the “private” codes are likely to quickly effect public laws, further blurring the distinction between them. We will encounter sequences of this kind when we look below at regulation of forest products, food safety in general, and production of certain commodities such as palm oil.

But there is an important qualification to this discussion of the sources of penalty defaults. Even if there are few limits on the potential availability of penalty defaults, in the sense that almost no domain is inaccessible to legal sanctions, moral pressure, or the exercise of power, it hardly follows that these sanctions will be regularly established where required. Legislative authority to pass a law gives no assurance that one will be passed, just as the existence of norms or of power relations says nothing about their actual exercise. Between the potential to impose a penalty default and actually imposing one there will be a fight – – among political actors, in the broader court of public opinion, or among parties to exchange, or all of them together.

The fight for penalty defaults to back XG regimes should be easier to win than fights for fixed emmissions reductions targets. Where the fights for fixed targets relied on apparently incontrovertible appeals to the authority of science, with the results we have seen, the fight for XG regimes explicitly acknowledges the uncertainty and complexity the actors face. Instead of insisting on deference to the mandates of science, advocates of XG call for agreement on framework goals and rules to be corrected in light of joint exploration of solutions. There is less reason to oppose the new initial commitment and more reason to think the differences will be informative, and lead to solutions rather than further conflict. But these advantages will have to be demonstrated case by case, unless and

until XG becomes a routine, default response to problems of uncertainty and complexity. For now, and for as far as the eye can see, even if it is easier to win the fight in favor of XG and penalty defaults than the traditional one, winning requires a fight all the same.

5. Some Theoretical Roots of XG: A Theory of Quasi-Evolutionary Transformation

So far, we have discussed these ideas as they are today—as XG has emerged in practice, especially in the reorganization of industry and regulation in response to uncertainty and complexity. We noted too that XG has intellectual forbearers in American pragmatism, particularly the idea that problems bring to light untenable assumptions hidden in habits and routines, and that problem solving guides the search for better alternatives.

But XG is also rooted in a family of quasi-evolutionary ideas: evolutionary because, as in natural selection, development proceeds by adjustment to constraints in the selection environment; quasi-evolutionary because the decisive initial constraints, which directive element towards a particular goal, are set by human intervention. These theories sought to explain how bottom-up adjustments, in response to local problems of public organization or opportunities for profit, could cumulate to transform economies, and the nature and boundaries of the state, given only a bare minimum of foresight by a few, key actors at the outset. Articulated in the 1950s and 60s, these ideas are still an influential if sometimes underground alternative to mainstream views of Inducing large-scale change through expert bureaucracies or markets. XG shares with these views the assumption that incremental exploration of possibilities is the most promising path to deep and enduring change. But these predecessor theories made the setting of foundational goals the province of political visionaries and economic and technical elites, and (infrequent) revisions likewise a matter for insiders. XG insists in contrast that under current conditions goal setting and routine revision must be open to explicit stakeholder deliberation. This openness in turn makes XG democratically accountable while the earlier concepts of governance of extensive change were not. By way of conclusion to this Chapter we look briefly at these precursors to XG and highlight the ways it differs from them.

A prominent example of these earlier ideas was neo-functionalism, associated with the work of Ernst Hass. It developed as an attempt to explain how national boundaries could blur and sovereignty pool in the emergence of the EU (then the European Economic Community) even in the absence of anything approaching an explicit, consensual authorizing plan. The core claim was that transformation in boundaries and problem-solving capacities of states can be result from incremental problem solving undertaken with little or no recognition of the overall result to which it was contributing, under two conditions.

First, there must be a fit or congruence between the long-term transformation and the requirements of survival and prosperity in the prevailing global environment. In the vocabulary of evolution on which the theory draws, the change must be adaptive. This adaptive fit is what makes the transformation functional. The second condition—which has more to do with human than natural selection—is that sufficiently influential visionaries—a programmatic elite—articulate the goal of the transformation with force and clarity, enabling decision-makers to take first steps, but only these, towards its realization.

Then a contrary method of decision-making comes into play: Halting efforts to realize the large goals produce unanticipated, thoroughly practical problems, with no apparent connection to the large visions informing them. These practical problems call forth practical solutions, new practical problems, and further solutions. This cascade produces the envisaged transformation, although the visionaries could not have anticipated the intervening steps and local decision makers do not realize the connection between particular decisions and the transformation in progress. On the contrary: decisions will be prompted and guided by pressures resulting directly from partially successful, partially unsuccessful solutions to earlier problems, not continuing reflection on the framing idea or continuing pressure from the external—international—environment. This internal problem pressure is what makes this variant of functionalism neo, and differentiates it from Darwinian selection, in which organisms of course have no intentionality at all and there is no directionality in their development.

In the 1950s and 60s, given recent and continuing experience with the easy and dangerous elision of planning, comprehensive thinking, totalizing ideas and totalitarianism, Haas' resolutely un-self-reflective and pragmatic approach to large-scale change was a recurrent trope in social science debate and policy discussion. Hirschman's idea of unbalanced growth is the leading example in development economics. Hirschman argued that it would be all but impossible for developing economies to finance and co-ordinate a program of industrialization that would be self-sustaining and balanced in the sense that investments in new productive capacities would generate, through additional employment, the demand for the goods they produced. Hirschman's unbalanced alternative was to create, through a single, strategic investment, a series of follow-on opportunities, each leading to the next and all together ultimately producing just the economic structure envisaged but unobtainable in the balanced scheme. Just as Haas's regional transformation was to be motivated and oriented by a visionary idea, so in Hirschman's concept the choice of the initial, dis-equilibrating investment—the one that touches off a cascade of complements—was to be determined by a privileged view of the whole: in this case to an input-output table indentifying central nodes in the (potential) economy: Investment in a steel mill induces investment in railroads and shipyards, which in turn open further markets. Again, decision-making is driven by practical—here profit-seeking—responses to a cascade of responses, and

transformative coordination is possible without—indeed because there is no—plan.

Lindblom's concept of muddling through generalizes these ideas of progress without a plan. Lindblom assumed that cognitive limitations—what we would now call bounded rationality or the distortions of uncounscious heuristics—made it impossible for decision makers to canvass all the possibilities that should evaluated in a fully rational determination of policy choices. In practice, current arrangements could be compared on relevant dimensions with the most salient alternative. The resulting choice was likely to lead to improvement in some regards, but there was no reason to think the new arrangement was in any sense optimal, and many (the unexamined alternatives) to think that it was not. By a succession of such choices, each guided by an immediately accessible, plausibly practical remedy to (some) pressing problems, institutions muddled through, preserving an acceptable fit between their internal routines and their environment, but never learning in the sense of drawing general conclusions about process of substance from their successive, pair-wise choices. Provided that the initial starting point was not a dead-end, muddling through would lead to improvements, though only by accident to optimal ones. In retrospect, then, neo functionalism was just one member of a broad class of procedures for solving extremely complex problems by economizing on the necessary cognitive resources, and in the bargain avoiding worrisome associations with plans and visions—but at the price of excluding the possibility of any ongoing reflection and reevaluation of initial goals.

In the event it was precisely the founding assumption that ongoing reflection and deliberate self correction were unnecessary to guide complex change that rendered neo-functionalism and related theories incapable of anticipating, let along proposing effective responses to developments that disrupted "spontaneous" transformation. Haas was especially forthright in diagnosing the dilemma when progress in the ECC stagnated in the 1970s. Borrowing a term from two Norwegian sociologists, he saw the fundamental obstacle to continuing integration on neo functionalist lines as an increase "turbulence:" growing uncertainty about possible states of the world. This uncertainty was partly the result of unpredictable, disruptive increases in (technical) problem-solving capacity, propagated by increasing global interdependence. But whatever its cause, the effect of turbulence was to undercut the unreflective incrementalism that both powered and steered regional integration. In a highly turbulent world actors were surprised by their environment often enough to learn that they had to reflect on, and sometimes alter their goals. But recursion—revising goals in the light of experience of (knowingly or not) implementing them was simply incompatible with the theory's founding assumptions.

Haas made a last and in many ways far sighted effort to adjust his ideas. In between the incrementalism of neo functionalism and the synoptic, rational-analytic approach--planning--that was its polar opposite, he inserted a new

category—"fragmented issue linkage": an "attempt to cope with disaggregated policies by periodic refocussing as new objectives are superimposed on older objectives." This "limited holistic perspective" was "designed to project failures of incremental 'solutions'; it depended on "partial scanning" of the entire system "to refocus problem, followed by continued disaggregated pursuit of specific policies within [the] whole."[25] But Haas diubted that institutions could in fact combine these features of bottom-up incrementalism and top-down planning "Fragmented issue linkage," he wrote, was "a purely analytic concept, and not accepted by the actors as a conscious strategy of action"(p. 25).

The emergence of XG would show that he saw farther than he knew.

6. Conclusion

The "turbulence" of the 1970s was in hindsight only the beginning. Since then uncertainty and complexity have not only persisted but increased—especially in the industries that will be central to addressing global climate change. Firms and regulators, we have argued, have come to accept both as a constitutive circumstance of decision-making. Firms in industries that are undergoing vertical disintegration are already practices in co-design with suppleirs and forms of production based on short learning cycles and deliberate exposure to vulnerability. Regulators, in varied ways are already exploring ways to shift from writing impractical, detailed rules to more plan-oriented approaches that are better suited to idiosyncratic contexts; they are increasing attention to post approval or ex post monitoring in addition to initial licensing. These changes are the seeds to a more institutionalized and pervasive recognition that initial decisions must be treated as preliminary, and subject to revision in the light of experience.

XG applies the underlying logic of this response to the institutionalization of the kinds of public-private policy choices of central concern earlier in the muddling-though family of theories and today in climate change among other domains. Goals are so open – – ill-defined, inaccessible and therefore open to revision – – that there is no visionary (as in neo-functionalist theories) nor a strategic investor (as in theories of unbalanced growth) to take a decisive a decisive first step that entails stumbling, but ultimately successful realization of a grant project that can never be called into question. For the same reason searches begin not from a single starting point, as in the early theories of decision-making under bounded rationality, but from many simultaneously; and these searches naturally result not in the pairwise comparison of the status quo to a salient alternative, as in muddling through, but in the mutually illuminating comparison of many, diverse possibilities. This peer review raises questions about the assumptions underlying each approach; together, and cumulatively they make possible explicit, formal

[25] Ernst Haas, The Obsolescence of Regional Integration Theory, 1975.

learning and deliberate questioning of ends and means that the earlier theories assume to be impossible.

These features distinguish XG from both hierarchies and markets. Bureaucracies are governed by rules that limit and often sanction the exercise of discretion. XG treats rules as rebuttable presumptions and openly encourages the exercise of discretion and joint reflection on it. Markets too are skeptical of rules: the job of the entrepreneur is to maximize profit by exercising discretion, guided by and subject only to the constraints and opportunities revealed in prices. Nothing in the nature of markets, however, requires that the reasons for decisions be make explicit, and subject to deliberation; the traditional presumption is rather that reasons will remain tacit or at least opaque to other market actors.[26] In XG, on the contrary, the requirement to explain decisions across levels makes it necessary to articulate both generally held and local assumptions that would otherwise remain unspoken in the background. XG thus differs from bureaucracy in encouraging the interpretation of directives and exploration of their limits, not rule following, and from markets, in fostering explicit learning, not tacit adjustment.

These features, finally, make it both necessary and possible to hold XG democratically accountable. Because agreement is initially limited to framework goals, and because joint exploration of possibilities requires the exercise broad discretion XG regimes must continuously legitimate themselves by cogently connecting their actual strategies to their founding purpose. Peer review requires participants in these regimes to do just that, allowing them and the wider public to learn from their differences more about what is feasible and more about the values implicated in their choices.

In the next chapter we show that institutions with these features are at the core of some of the most successful responses to climate change.

[26] We say “traditional” because as firms shift to co-development and just-in-time production they introduce requirement for reason giving on XG lines.

CHAPTER IV. Getting History Right: Experimentalism and Evolution Three Ways

The idea of experimentalist governance emerged though study of the response to uncertainty of innovative firms, and administrative and regulatory systems in the US and the EU. But do the ideas travel? Are they applicable to the problem of emissions reductions central to addressing climate change? Are they applicable to international organizations grappling with these problems? Here we suggest the answer is yes to both questions. Donning a pair of XG glasses helps bring into focus three iconic successes of environmental regulation that in our view have been largely misunderstood. All share common characteristics that will be familiar from the discussion of experimentalism. They begin with at least a thin consensus on the need for action. That consensus is inspired, often, by the fear of a penalty default—an outcome imposed in the absence of cooperation that is more onerous to the key players than results they could have achieved had they collaborated in devising a solution. That thin consensus allows for the setting of provisional goals and the launching of experiments. Flexibility in those goals and means allows for revision in light of experience. Policy makers and regulated firms work together to narrow uncertainties—breaking big problems down into more tractable components and then using the initial, partial solutions to guide further efforts. Over time, these groups of policy makers and firms can take on larger regulatory, technological and behavioral challenges as innovation and learning in each partial domain generate economies or scale and scope, reducing the cost of incremental problem solving and connecting individual components into more integrated policy and industrial responses. Through this process the initial stakeholders learn what is feasible and new interest groups emerge that favor more ambitious goals. As outlined in chapter 3, XG offers an explanation for the dynamics of regulatory behavior. It is not a simple story of principals delegating to agents the task of regulation. Instead, the very process of regulation changes what the principals want as well as what organized industrial coalitions seek. In the best cases what, in early rounds, looked like insurmountable barriers to progress become, in later rounds, the starting points for more demanding regulation.

The three cases are the CFC-reducing Montreal Protocol, the deep cuts in air pollution orchestrated by the California Air Resources Board (CARB), and the SO_2 cap-and-trade trade regime. The Montreal Protocol is perhaps the most successful international environmental agreement. CARB is widely seen—and emulated both within the US and internationally—as a highly successful system for regulating air pollution. And the sulfur emission-trading program was the world's first large market-based approach to pollution control. These are not the only or best cases for testing XG theory. But given their diversity—the first an international regime; the second a State regulatory body; the third arising under Federal legislation—their common success suggests that XG processes operate under a wide range of institutional and political background conditions even in a

country—the US—with a legal culture often thought inimical to regulation that goes beyond codifying (good) current practice.

These three iconic cases have generated misleading policy folklore. Montreal has come to stand for the idea that the best way to obtain strict international limits on pollution is to impose them top down through an integrated treaty. CARB stands for the idea that a jurisdiction with strong political will can create regulators independent enough to write technology-forcing rules (in this case concerning reductions in auto emissions) obligating industry to advance far beyond the frontier of current practice. Together, the Montreal Protocol and CARB have also become emblematic of the crucial role of science in the formation of such political will. Both succeeded, it is thought, because alarms sound be science first energized consolidation of the political determination to attack a particular climate change problems; and political determination, backed by the apparent incontrovertibility of science, elicited an (almost) automatic, successful response by industry. The conventional lesson of the SO_2 regime, in contrast, is that market mechanisms, unencumbered by direct or targeted government intervention, are best suited to producing pollution abatement. The logic of emission trading, conventionally understood, is that when government seeks a technology-forcing transformation of existing arrangements political will embodied in regulatory authority should take a back seat let the market in figuring out how to achieve the desired outcome.

In this chapter we argue that the standard wisdom about success in all three of these cases is incorrect. Success in all three depended on XG institutions that have no place in the standard accounts about why regulatory and market institutions were able to control pollution. Political will for action was not nearly as strong at the outset as generally assumed, nor were regulators and policy makers as close to omniscient, nor were firms nearly as passive in response to proposed regulation. Rather, firms and regulators learned together what was feasible, and their ability to do so bolstered political will.

The Wisdom of Montreal

Atmospheric scientists discovered in the 1970s that chlorofluorocarbon (CFCs) and other chemicals would deplete the ozone layer through catalysis. Each molecule of these chemicals—which are widely used in spray cans, for blowing Styrofoam, as refrigerants and in fire extinguishers—would destroy hundreds of molecules of ozone.[27] Acting on this news, from the middle 1970s to the middle 1980s some countries regulated these substances. Meanwhile, scientific assessments of the ozone problem ebbed and flowed on the severity of depletion that could be expected. By the early 1980s scientific consensus suggested that

[27] Molina and Rowland 1974.

depletion might not be as bad as originally feared.[28] But then, in 1985, a "hole" in the ozone layer was detected exactly in the place where ozone should have been the thickest: over Antarctica after the winter. (The normal chemistry of ozone depletion required sunlight and thus dark places in the upper atmosphere should have allowed for the greatest accumulation of ozone—safe from destruction.)

The unexpected appearance of an ozone hole was a reminder that the science was far from settled. Systematic national assessments helped to narrow the uncertainties and also articulate what was known. And internationally an assessment organized by the World Meteorological Organization, NASA and several other organizations helped to establish a single, authoritative voice for the state of the science—the first of those international assessment reports was issued in 1985.[29] Two years later--and after only three years of diplomacy--the Montreal Protocol was agreed.

The hallmark of the Montreal Protocol is the treaty's detailed schedules of commitments to cut ozone-depleting substances (ODS). The earliest targets adopted in Montreal were relatively easy—because they largely codified what countries were (or could readily) do at home. Most CFCs were cut in half. For the US, where a ban on many CFCs was already in place, halving CFS emissions was easy because regulators were already mobilized on the topic. For most of Europe and Japan, where no ban was in place, US experience soon demonstrated that it was feasible to eliminate use of CFCs in aerosols and other applications.

But for Montreal to evolve beyond this first step the institution needed to solve three problems. a) it needed to ratchet down existing commitments at a rate that countries would tolerate; b) it needed to expand the regime to identify new chemicals in a way that led to overall lower atmospheric levels of the ingredients that actually depleted the ozone layer (Chlorine and Bromine). And c) it needed to engage developing countries, which meant setting commitments at levels they would tolerate and identifying exactly how much it would cost to compensate them.

The institution solved these problems by marshaling ground-level technical expertise. To set reductions that would be feasible for countries and key firms governments quickly created a system of "essential use" exemptions[30] and established Technical Options Committees (TOCS) in sectors such as solvents, refrigerants and halon fire extinguishing agents to determine the availability of

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[28] NRC 1983.

[29] NOAA 1985. Perhaps the most definitive of these assessments was the 1988 Ozone Trends Report (NOAA 1988), which established a definitive link between trends in depleted ozone and the presence of CFCs, Halons and other halogenated substances.

[30] [DGV action: need to get more detail here on who proposed the scheme and how it got advanced—it was a blend of the institution itself and sympathetic governments.]

substitutes or the capacity to develop them. The TOCS operate through working groups of users and producers, which visit plant visits to evaluate alternative ODS-free processes, examine improved logistics, and pilot projects involving new substances. To limit the risks of capture producers are not formally represented on TOCS.

If a very strict obligation to cut ODS conflicted with a high value use—for example, the ability to blow specialized foams needed for the space shuttle or the ability of asthmatics to obtain metered drugs through CFC-propelled inhalers—the TOCs issued a time-limited exemption for that particular use. As many of these chemicals were ratcheted down to zero the need for this safety valve grew—in effect, a race was on between the efforts to reach zero and the efforts to find acceptable alternative chemicals. If the race to zero ran too quickly the regime faced a political backlash.

By setting zero as the goal the parties to the Montreal Protocol sent a credible signal to the industrial firms that there would be a demand for new, alternative products. Industrialists then ran experiments to see what would work—knowing that when credible alternatives were verified in the market that the exemption would be removed and the size of the market for the alternative instantly enlarged. Perhaps the best illustration of this process was with metered dose inhalers (MDIs)—a drug delivery device that used ODS chemicals (because they were inert) as the propellant. Exemptions for MDIs—with individual quantities set for each country where these drug delivery devices were sold—were reviewed annually with technical experts (some drawn from industry, others independent) determining whether alternative MDIs had demonstrated adequate performance for each of the drugs they delivered. Once 2 to 3 alternative models were established as safe the exemptions were quickly removed. Through this approach the technical committees helped to greatly reduce the uncertainty that often plagues regulation—creating an incentive for innovating firms to provide accurate information while reducing the ability of any individual firm to corner the market.[31]

The second front was probably even more important. Again the TOCs played a key role: Each round of target-setting would begin with a technical assessment of the level of regulation that was feasible. The assessment would include a forecast that linked regulatory efforts to the ultimate level of active chlorine and bromine in the upper atmosphere—and thus the ultimate impact on the ozone layer.[32] The importance of this approach was particularly evident when regulating chemicals for which the industrial politics did not favor a phase-out . For example, in 1992 the Montreal Protocol was amended to include methyl bromide—a chemical that depleted the ozone layer because it contained

[31] Victor and Coben 2005.

[32] Parson 2005.

bromine. While CFCs and were produced by firms that saw some economic potential (or no meaningful loss) from regulation,[33] methyl bromide was used principally as a fumigant by agricultural producers (to ship their products long distances with minimal spoilage) who feared they only stood to lose from change as substitutes would be costly or unavailable. By framing the options for methyl bromide control the TOCs helped governments approve new regulations to reduce uncertainty about costs and indicated strategies for deeper cuts as new, alternative techniques were proven (and approved by food safety regulators). Independent technical assessment thus made it easier for governments to manage political opponents (agricultural interests using old technology) as well as the uncertainties created by technical and regulatory unknowns.

The TOCs provided key guidance regarding not just the rate of phase out but also its cost. A separate mechanism—the Montreal Protocol's Multilateral Fund (MLF)—then paid the "agreed incremental cost" to developing countries that were members of the Protocol. (And for those that weren't, the Protocol threatened trade sanctions to forcefully encourage membership.) This transformed the politics of cutting ODS from a contest between industrialized countries (that cared a lot about the ozone layer) and developing countries (that professed to care little) into a much simpler problem of targeting income transfers that, to date, total about $3.1b.[34] But that political transformation depended on institutional innovations that allowed calculations of cost and held members accountable for their actions.[35]

Though it figures prominently in many detailed accounts of the operation of the Montreal Protocol, the importance of the review mechanisms has been largely overlooked in studies of the politics of climate change. The conventional view of the Montreal Protocol is that it "worked" because the ozone problem was "easy" to address or because governments set ambitious targets and the market found ways to comply.[36] A close look at the history, though, shows that Montreal worked because the regulatory system found ways to stay closely connected to technical assessment. As Ted Parson, a leading scholar of the ozone regime, writes:

> Although the Protocol's adoption of concrete international CFC controls represented an important first step, these provisions for repeated review and modification of its control measures represented the most central contribution to the ozone reduction regime's subsequent adaptation and ultimate success.[37]

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[33] Oye and Maxwell 1994.

[34] UNEP 2015.

[35] Desombre and Kauffman 1996.

[36] Greene 1998; Victor 1998; Parson 2003; Barrett 2006; Victor 1995.

[37] Parson 2005, 231.

The ratchet was important in Montreal. But keeping the ratchet connected to reality was even more important.

So far we have focused on the role of XG-style technical assessments and feedbacks in making an important international institution more effective. Now we turn to one of the most successful regulatory systems operating within a country—CARB. We might expect that international regulators would be starved for reliable information and thus need special systems for obtaining information and encouraging experiments. Now we shall see that the same generic challenges confront even the most powerful regulators in the most advanced systems of regulatory administration.

What was Miraculous in the California Miracle?

Smog is an unhealthy urban pollutant, primarily composed of ground-level ozone, produced by the reaction of nitrogen oxides (NO_x) with hydrocarbons (VOCs) released by combustion in motor vehicles and industrial operations. California, whose cities had (and have) some of the worst air quality in the nation, has since the 1960s pioneered successful regulatory efforts in the US to limit emissions of smog precursors and other important vehicular pollutants. Because of its pioneer status the Clean Air Act of 1970 allows California, alone among the states, to set its own emissions standards, provided they are at least as protective as the national ones; under the statute other states may, and often do adopt the (unaltered) California standard. By these mechanisms California has set the pace, especially in recent decades, for reduction of vehicular emissions in the nation as a whole: Smog levels in California have dropped by 60 percent since the 1960s, even though the number of cars on the road has doubled. [38] Today, fifteen states have adopted California's standards; about one-quarter of all the vehicle miles travelled in the nation occur in states that follow California rules. ***39***

CARB has regulatory authority for protecting the quality of the state's air. CARB's board has 12 members, including by statute one with experience in automotive engineering, one with training in chemistry or meteorology, one with expertise in medicine or health, one with experience in air pollution, and two representatives of the general public. Each of the remaining six members represents one of the state's air pollution control districts.***40*** By design CARB thus reflects view from a variety of stakeholders and creates a forum where lessons learned in one control district can be rapidly transferred to others.

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[38] Gardner 2014.

39 [recheck number]

40 Cal. Health and Safety Code § 39500, 39510; Reed 1997.

In 1990, in part in response to amendments to the Clean Air Act in that year, CARB introduced the Low-Emission Vehicle (LEV) and Zero-Emission Vehicle (ZEV) programs. Together they established stringent standards for reduction of exhaust emissions from gasoline and diesel vehicles of smog precursors such as NO_x, nonmethane organic gas (NMOG), and carbon monoxide (CO).[41] Standards in both programs were formally amended a number of numbers (the LEV standards in 1999 and 2012, for example) and continuously revised between formal amendment. Both programs were successful. The LEV Program's ambitious standards drastically reduced smog emissions by inducing incremental innovations of the gasoline- or diesel-burning internal combustion engine that have, over time, cumulatively radical effects. A new car sold today in California emits 99 percent fewer pollutants a new car in the 1960s.[42] The ZEV program—designed to encourage volume production of cars with "no exhaust of evaporative emissions of any regulated pollutant"—helped induce development of affordable batteries that could meet range and chargeability standards akin to conventional vehicles and be generally acceptable to consumers—an extraordinarily ambitious goal given existing technology. ***43***

By the standard wisdom, ZEVs and LEVs were classic examples of what CARB does best: it identifies a serious problem and moves, independently, to fix it through the imposition of strict rules that force changes in industry. It demands the impossible of industry, and because industry needs the California market (as well as other markets that often follow California's lead) it finds a way to make the impossible possible—in short, the "California effect."

But this characterization of the California effect is misleadingly incomplete. Access to a crucial market mattered, to be sure. The threat of exclusion created a penalty default to sanction the failure to cooperate. Yet by themselves the incentives created by this penalty default would no more have guided the actors to workable solutions than the incentives created by commitments and sanctions under the Montreal Protocol would have yielded results without the guidance provided by the TOCs. California's success also and crucially depended on the ability of its regulators to couple development of regulatory standards to ongoing evaluation of the possibilities of critical and rapidly changing technologies such as pollution control equipment and electric vehicles. In practice the LEV and ZEV Programs generally accelerated progress in emissions control because, as a leading commentator put it, the regulator was "committed to a continuous process of implementation oversight and regulatory review," and was correspondingly willing "to adjust and change the basic program."[44]

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[41] California Air Resources Board 1994. California has consistently failed to meet either standard.

[42] Telephone Interview with Paul Hughes, Manager, Emissions Compliance, ARB (Dec. 2, 2015) ("Paul Hughes Interview").

43 Id at 5. [need a good cite for success of program]

[44] Reed, 1997, p. 785.

CARB was in part pushed to link standard setting to continuing investigation of technological development by the feasibility requirement in Section 202(a) of the Clean Air Act, by which the EPA and other regulators must demonstrate that available technologies can cost-effectively meet any proposed standard. A line of court decisions including *International Harvester v. Ruckelshaus* and especially *NRDC v. EPA* suggested that long lead-in times for new requirements, providing the possibility for correcting unworkable rules, in effect assured feasibility.[45] Thus the court in *NRDC* acknowledged that "the time element in the EPA's prediction…introduces uncertainties in the agency's judgment that render the judgment subject to attack,"[46] but found

> [T]he presence of substantial lead time for development before manufacturers will have to commit themselves to mass production of a chosen prototype gives the agency greater leeway to modify its standards if the actual future course of technology diverges from expectation.[47]

But the need to link standard setting to active engagement with technological developments was also reinforced by the widespread recognition within CARB, from the outset, of the uncertainty of the overall situation and hence the need to learn rapidly to stay abreast of possibilities. A December 1995 briefing to CARB on "Making ZEV Policy Despite Uncertainty" by the RAND Institute for Civil Justice put this directly. One of its conclusions was: "Enormous uncertainty and risk suggest a search for near-term policies that, a) enable learning, b) are not susceptible to disaster, and c) can be tailored as new information is obtained."[48] Learning and corollary policy updating was central in the minds of CARB from the early days of the LEV and ZEV mandates.

Collaboration between regulator and regulated entity was greatly facilitated by deep changes in the organization of the automobile industry. Until the 1980s the major automobile companies were vertically integrated. They developed and produced key components in house to avoid the risk that a powerful supplier could withhold delivery of a crucial component unless the supply contracted was renegotiated in its favor. But as markets became more volatile and the direction of technological development more uncertain the risks of owing captive suppliers increased dramatically: a shift in the trajectory of development could make in-house capacity irrelevant, while a shift in the level or composition of demand could make it superfluous. Beginning in the 1990s, automakers divested internal suppliers and purchased more and more components and subsystems from independent manufacturers.

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[45] Int'l Harvester Co. v. Ruckelshaus, 478 F.2d 615 (D.C. Cir. 1973); Natural Res. Def. Council, Inc. v. U.S. Envtl. Prot. Agency, 655 F.2d 318, 329 (D.C. Cir. 1981)

[46] Natural Res. Def. Council, Inc. v. U.S. Envtl. Prot. Agency, 655 F.2d 318, 329 (D.C. Cir. 1981)

[47] Id.

[48] Dixon, Garber, and Vaiana 1996, 7.

An unintended side effect of this restructuring was to shift the balance of power in relations between the regulator and firms in the industry. Vertical disintegration create important new actors (primarily equipment suppliers) with interests in reducing the levels of polluting emissions even if this improvement was in tension with the final assemblers' goal of minimizing overall costs. Thus component manufacturers and suppliers frequently approached CARB to pitch new emissions control technologies. By demonstrating the superior performance of their products they may well influence emergent standards and create markets for their innovations.[49]

This reconstitution of interests reduced the information asymmetry that traditionally advantages producers, knowledgeable about the risks they generate, in negotiations with relatively ignorant regulators. Indeed, suppliers and component manufacturers developed many of the newer emissions-control technologies, such as turbochargers, and electric superchargers;[50] and the first LEV standards, in the late '90s, were shaped by the demonstration of an electrically heated catalyst that drastically reduced emissions.[51] Thus CARB's does not conduct its own feasibility assessments in a vacuum—rather, they are the result of near-constant conversations with both component manufacturers and automakers. Although virtually all automakers belong to trade associations that lobby regulators on their behalf, CARB emphasizes communications with the automakers themselves, regularly recruited experienced engineers from the auto industry to build its capacity to engage in detailed technical dialogue with component and carmakers.[52]

Note that the continuing exchanges between firms and the regulator set performance standards, but do not mandate the use of particular technologies to achieve them. Once the feasibility of a certain reduction in emissions has been demonstrated, each firm is free to find its lowest-cost path to the required result; and in fact automakers very often devise their own means for meeting new standards. For example, although CARB staff projected "that gasoline vehicles meeting the more stringent [LEV] standards would require the use of emerging new technologies such as electrically-heated catalysts (EHCs) and heated fuel preparation systems,"[53] only one manufacturer ever used an EHC;[54] others used

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[49] As one senior regulator put it in an interview, "[a manufacturer might say] 'Look, I have this product, and I think it can be really cost effective and I think it can really lower emissions' or 'I have the data to show you I can do it, and I can do it better than my competitors and I can do it cheaper.'"Anna Wong Interview

[50] Jeff Cherry Interview

[51] Paul Hughes Interview

[52] Because of this expertise CARB can "meet with manufacturers and we can roll up our sleeves and talk technical talk with them. It got us a lot of respect with them." Michael McCarthy Interview.

[53] California Air Resources Board 1996, at 4-5 ("1996 Staff Report").

[54] Paul Hughes Interview.

(and further developed) their expertise in systems integration to realize[55] "improvements in combustion control in the engine itself to reduce engine-out emissions."[56] The real contribution of joint exploration of new technological possibilities, in other words, was to demonstrate daunting, technology-forcing problems could be solved, not to determine, and still less to impose, required solutions.[57]

The frequency and scope of these technological enquires varies according to circumstance. The general rule is that the more uncertain the technological foundation of a proposed standard, the more extensive and frequent the review, but of course the requirements of administrative process and concerns regarding possible judicial review influence the assessment regime in particular cases as well. [cite?] The staff reports accompanying every proposed rulemaking or amendment synthesize the results of these exchanges in surveys of recent advances in pollution control technology, identifying those which CARB expects automakers will use to achieve new standards. For example, when CARB initially proposed amendments to the first LEV standards in 1996, the agency produced a Staff Report that identified "four basic aspects of current emission control systems that vehicle manufacturers have been improving to achieve low-emissions levels, [namely] more precise fuel control, better fuel automation and delivery, improved catalytic converter performance and reduced base engine-out emissions levels,"[58] listed nineteen potential low-emission technologies that would become available when the new standards took effect, [59] and predicted which technologies manufacturers would use to meet the new requirements.

As an illustration of this continuous, joint assessment, consider CARB's biennial review of the continued technological feasibility of the ZEV program targets.[60] This review, and the related assessments to which it gave rise, proved essential to effective pursuit of the ZEV mandate despite the uncertain technological developments on which it depended.

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[55] See Magnussen and Berggren 2009: "Hence, systems integration still constitutes a critical activity in automotive development and design. Even though automotive manufacturers do not have to manufacture the complete vehicle in-house, they still need a broad technological knowledge base to be able to absorb new technologies (Cohen and Levinthal, 1990), as well as to understand interdependencies in the product system and cope with imbalances due to different rates of development in different technologies (Brusoni and Prencipe 2001)."

[56] Paul Hughes Interview; see also 1996 Staff Report at 4.

[57] Michael McCarthy Interview. One regulator described the push-pull dynamic created by CARB's feasibility requirement: "we have to know when we adopt the more stringent standards, there's a way to get there. And of course, they have to know there's going to be a market for the product they come up with."

[58] 1996 Staff Report at 4.

[59] Id at 5.

[60] Reed 1997, 722-23.

The first review, in 1992, and conducted under the pressure of various procedural deadlines, was limited to perfunctory approval of the initial ZEV requirements.[61] CARB staff then continued consultations with emission control suppliers and the volume vehicle producers; conducted their own tests of components and prototype vehicles; and reviewed the findings of the United States Advanced Battery Consortium (USABC), a collaborative research project supported by the large auto manufactures. At the second biennial review CARB again found that the LEV and ZEV requirements were feasible and cost effective, but extended the review process itself in two ways.[62]

First, given the centrality of battery development to the ZEV program, CARB established an independent Battery Technology Advisory Panel (BTAP) to assess candidate technologies by visits and follow-on discussions with leading developers of advanced batteries and their customers.[63] Second, in response to questions raised during the review, CARB staff organized a series of public workshops and other fora, from May to November, 1995, in which interested parties ranging from electric utilities to environmental groups and auto manufacturers discussed key ZEV issues such as electric-vehicle infrastructure and the marketability of ZEVs. In the course of these discussions proposals to modify the ZEV mandate were introduced, and the CARB convened a public meeting to consider these and other possible modifications in anticipation of the third biennial review the following year.[64]

On the basis of these consultations, and a review by the BTAP, CARB concluded that ZEV technology would not be available in time to meet the 1998 requirements.[65] Battery prices had not fallen as quickly as expected; the industry feared that premature introduction of ZEV models at high-prices would produce consumer resistance complicating future sales of ZEVs.[66] Acknowledging these concerns, CARB removed the ZEV requirements for the 1998 through 2002 model years, but left the mandate of a 10 percent share of ZEVs in the 2003 fleet in place.[67] In exchange for this relaxation of the rules, CARB entered into a memorandum of agreement (MOA) with each of the large-volume manufacturers. These MOA bound the manufacturers to continue development of low-emission cars, to produce cleaner cars nationwide and to participate in advanced-technology development and demonstration projects, to share propriety development information with CARB, as well as to commit substantial funds to

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[61] Reed 1997, 723.

[62] Reed 1997, 733-734, 737-740.

[63] See The Year 2000 Battery Technology Advisory Panel 2000.

[64] Id at 57. [check this references against Jackson's memo]

[65] Bedsworth and Taylor 2007, 7.

[66] Reed 1997, 771.

[67] Reed 1997, 774.

support the of research of USABC. As under the original LEV program, noncompliance was sanctioned by substantial damages.[68]

The 1998 and 2000 biennial reviews recognized that battery development for ZEVs continued to disappoint. Yet very low-emission vehicles were developing faster than expected. As a result, CARB create new vehicle categories—the partial-zero-emission vehicle (PZEV) in 1998 and the Advanced Technology PZEV (AT-PZEV).. Cars that met the criteria for these new categories—mainly hybrids and plug-in hybrids—were less polluting than any that previously qualified as ZEV.[69] CARB therefore allowed manufacturers to meet their ZEV requirements by, for example, counting 5 PZEVs as equivalent to one ZEV. CARB formalized such substitutions as the "Alternative Compliance Path" in the 2003 Amendments to the ZEV mandate.[70]

As experience unfolded, CARB kept adjusting the targets so that the regulatory requirements and understanding of technical feasibility changed in tandem. In the 2007 biennial review CARB delayed the increases in the fuel cell requirement, judging technology not mature enough for application. But electric vehicles were. By 2011, there were 17,000 electric car sales and in 2012 that number tripled to 52,000. In 2013, there were 16 ZEV models available from eight auto manufacturers—9 of them purely battery operated. Currently nearly every major automaker has a ZEV for sale.

Along the way the automakers repeatedly challenged CARB's authority for adopting technology forcing requirements that were not feasible; CARB successfully defended by showing that its administrative process engaged the industry and remained aligned with the latest technical information.[71] Far from freezing development, uncertainty about whether the automakers would prevail in was a prod to innovation—neither individually nor in a consortium could firms run the risk of halting their own research while at least some competitors were likely to plunge ahead. This continuing innovation generated new ideas and technologies that, in turn, allowed CARB to keep tightening the performance standards and better defend itself against legal challenge.[72] Similar challenges have been raised about CARB's authority in other domains—such as in the regulation of carbon emissions that affect inter-state commerce—and CARB defended itself with similar arguments about grounding its work in impartial, technical competence backed by transparent peer review.[73]

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[68] Reed 1997, 774-775.

[69] Bedsworth and Taylor 2007, 7-8.

[70] Bedsworth and Taylor 2007, 8.

[71] Reed 1997.

[72] [Flesh out with help from Jackson Salovarra.??]

[73] Rocky Mountain Farmers Union et al. v. Corey 2013.

As the technology improved—this time unexpectedly to favor electric vehicles even as fuel cells had been expected to excel—CARB has changed the rules again. In January 2012, CARB approved a new emissions control program for model year vehicles 2017-2025—a new scheme called the "Advanced Clean Cars Program" which mandates more ZEVs with greater controls of the pollutants that are precursors to smog, including soot, and also focuses on cutting emissions of greenhouse gases. The new rules also include an over-compliance rule that allows manufacturers who over-comply with some rules to earn credits that can offset a portion of their ZEV requirement in 2018 through 2021. For regulators, this approach not only offers flexibility to manufacturers—a key demand from some in the industry—but also creates incentives for more advanced experimentation that can be used by CARB to reveal places where future rules can be tightened.[74]

Given uncertainty, the ZEV mandate predictably did not operate exactly as envisioned in 1990. Precisely because it kept responding to new and often unexpected developments, the program did nonetheless achieve its goals of advancing battery technology for vehicles and reducing emissions of harmful air pollutants. Though these advances did not immediately translate into a cost-effective battery electric vehicle, they did underwrite the explosive growth of hybrid electric vehicles in the early 2000s.[75] In turn, the development of hybrids has translated back into substantial development of pure battery EVs in recent years. As of 2010, California has 2.2 million electric vehicles on the road, 80.8% of which are PZEVs (mostly hybrids), 17.6% are AT-PZEVs, and 1.6% are ZEVs.[76] The ZEV share has likely increased since 2010 due to increasing sales from Tesla and other manufacturers.[77]

Similarly, the ZEV mandate had significant impacts on vehicle emissions reductions despite its modifications. [78] The history of the LEV program is marked by the same continuing creation and adjustment of joint assessment methods partly in anticipation, partly in reaction to unfolding technological and market developments.

In sum, the LEV Program and ZEV mandate came to include the essential components of an experimentalist governance regime. Specific targets for reduction in ozone precursors and other air pollutants set an initial, high-level goal. CARB served as a coordinating central body for an iterative learning process structured around the biennial reviews of the ZEV program and many other fora. On the basis of pooled reports of extensive field experience with

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[74] Somewhere we need to riff on "point to surface" strategy dating back to the 1920s (Heilmann 2008). Start with a microcosm that then expands. Places compete to become a pilot. And then they compete to be the best one. And then the best is socialized.

[75] Dixon, Garber, and Vaiana 1996, 11.

[76] California Air Resources Board 2012.

[77] DGV to get data and update.

[78] Bedsworth and Taylor 2007, 13.

implementing the regulatory mandates CARB periodically, and sometimes very substantially, adjusted its requirements. A penalty default—the threat that uncooperative behavior could ultimately result in exclusion for a leading market, as well as civil penalties for failure to meet the program's substantive goal—existed at the outset.

The legal pressure for feasible standards exerted by the CAA and well as the need to learn rapidly in the face of technological uncertainty encouraged CARB to collaborate closely with industry in defining standards. Vertical disintegration reshuffled interests in the auto industry, creating will and highly capable interlocutors for the regulator. The memoranda of agreement of 1996 directly incentivized industry participation in technology development; CARB's practice of adopting mutually beneficial regulatory compromises kept industry engaged. CARB's practice of amending its standards whenever demonstrably feasible, coupled with these changes created a cascade of innovation, first in individual components and novel emission control systems by suppliers, later in system integration by the final assemblers. Together these changes have created a market for pollution control technology and spurred incremental innovation to the ICE that, over time, has resulted in radical technological gains. As one senior regulator put it in a recent interview, today "there's almost [a] competition between some of the manufacturers; they want to achieve the lowest emission standard the quickest."[79]

In the end the lesson of CARB's success is not technology forcing succeeded because the regulator, as gatekeeper to an important market, could apply great force. Rather the lesson is that technology forcing is possible when, against the backdrop of penalty defaults, it is institutionalized as an ongoing exchange of information clarifying what could in fact become feasible.

The Collaborative Backdrop to the SO_2 Regime

SO_2 was one of the most noxious pollutants from coal plants in the 1970s and a leading cause of local air pollution problems as well as acid rain. When the CAA was adopted in 1970, SO_2 was one of six listed priority pollutants and EPA was instructed to require states to cut emissions so that air quality standards—which were set on the basis of public health needs without consideration of cost—would be met. At the time, nobody knew how to cut SO_2 from power plants, and the leading technology—scrubbers—had not been tested at scale. The cost, performance and reliability of scrubbers—as well as the impact of scrubbers on the overall operation of a power plant—were unknown.

[79] Paul Hughes Interview.

The industry responded when one of the largest firms—Southern Company—agreed to run trials on some of its own power plants and embed those trials in a new research institution, the Electric Power Research Institute, which would provide independent oversight and socialize the lessons across the industry. Over several years the technology was proven through tinkering at each site—after this experimental period the equipment then became ubiquitous in the U.S. coal fleet and eventually worldwide.***80***

From the 1970s through the 1980s a first wave of efforts to cut SO2 was implemented through standard regulatory instruments, rooted mainly in the CAA. This initial regulatory-driven process followed the standard logic of XG. The CAA enshrined ambitious goals (clean air) into federal law and empowered EPA as well as state environmental regulators to act on behalf of the public interest. Despite the mandate for deep emission cuts needed to clean the air, no actor knew exactly how to achieve that outcome or what a solution would cost. Thus EPA routinely issued waivers for states that were making progress—all conditional upon regularly demonstrating updates and all under the threat that EPA could, in effect, take control over a state economy by imposing a federal pollution control plan.[81] The credibility of that threat—the penalty default—was unknown but potentially onerous. The regulated utilities realized for their part that if they found cost-effective ways to control emissions they might profit from some of the savings—especially where regulators where not fully aware of the size of the gains. As scrubbers improved the EPA classified them a "best available control technology" and thereby in effected mandated their ubiquitous application. EPA's use of waivers—the means by which EPA adjusted goals in light of new information—was curtailed. And although the CAA rules applied mainly to new plants, over time legal challenges and EPA's own interpretations expanded the definition of "new" to include many existing plants that had gone through overhauls.[82]

In the late 1980s the political stars aligned for another big change in federal law on clean air—what became the 1990 Amendments to the CAA. This change in law offered another opportunity for many actors outside EPA to alter agreed goals and procedures. It also led to the creation of a new suite of policy instruments: markets.[83] The idea of using markets to control pollution was not new. The theory dated back at least to the 1960s; and in the 1980s a coalition of academics, environmentalists and industrialists helped articulate to policy makers the benefits and modalities of market-based pollution control.[84] A large lead trading program had demonstrated the practicality of cutting compliance costs

80 [Cites to EPRI history of scrubbers]; Heys 2013.

81 [cite to literature on SIPs and waivers.]

82 [add refs to NSPS controversies.]

83 EPA, 1990 Clean Air Act Summary.

84 Project 88, 1988.

through market strategies—albeit in the context of a rapid phase-out of a pollutant for which substitutes were already well known. [85] Under the 1977 Amendments of the CAA there were limited opportunities for trading of pollution offsets and credits.[86] Despite the limits of this experience, retrospective studies showed that markets usually saved money. In an epoch that was increasingly turning to market mechanisms as an alternative the failed bureaucracies associated with the New Deal, and with a market-oriented President and bipartisan legislation the 1990 Amendments to the CAA created the conditions for the first full scale demonstration of cap-and-trade.

It is easy to forget how little was known about emissions trading when the new market was established. At the time, US emissions were about 20 million tons of SO2 per year. The best estimates suggested that costs of emissions reductions would rise steeply after 10 million tons—or a cut of half the output of the pollutant. [87] A reduction by half was also within the range of what many environmental groups would accept; it was a dramatic and precise enough goal to quickly become a focal point for policy. It was also clear that most emissions came from a small fraction of power plants and that early action at these hot spots would produce quick and significant results. The big polluters also soon discovered early action was in their interest since emission credits would be given out pro rata, for free, to existing emitters (unlike an emission tax system, which would have taxed the existing emitters the most). In addition early action offered the opportunity to earn in credits that could be banked for the future.

When the 1990 Amendments came into full effect the market, indeed, produced big changes. As legislated, emissions were cut in half. And as anticipated the costs of control were lower than if traditional regulatory approaches had been applied to all plants. Some of that saving came from true flexibility in letting firms choose exactly which technologies to install—a central benefit of market-based strategies. But [most/half] came from unexpected benefits that made the task of emission control much easier. One was the unexpectedly rapid appearance of substitutes for CFCs. Even more important was fortuitous railroad deregulation in these years that made it possible for power generators in the Midwest to switch to and cheap, low-sulfur western coal.

What is seen in retrospect as a big success for market-based strategies was actually the maturation of technology that had been proven, initially, by decomposing the sulfur problem into particular, discrete technical components and then forcing changes in light of new technical information. Studies of the rate of technological change in the industry find that innovation was highest during the period of greatest regulatory pressure and lowest when markets were

[85] Cite history of lead trading.

[86] Hahn and Hester 1989.

[87] cite to Schmalensee history of his CEA time.

at work.[88] It is a misreading of that history to conclude that markets are not effective. Its real lessons concern where and why different policy strategies work best. When problems are huge and uncertainties about control strategies are paralyzing t XG-like regulatory systems work best. All parties have an incentive to work on solutions, and the regulator knows that goals must be treated as provisional and adjustable in light of experience. In that setting, markets by themselves are likely to fail—indeed, regulatory adjustments and uncertainties are widely seen as the central reason why market-based offset strategies under the 1977 CAA failed to achieve much.

Once goals can be set more firmly and the range of technological and behavioral options is better understood then markets can be much more effective—in practice, yielding large static gains in efficiency. Part of this logic is intrinsic to the market, which can't function reliably in the face of paralyzing uncertainties. Part of it political—environmental goals are the result of political processes, and as the stakeholders learn what is feasible they will adjust the goals and standards. As the CARB example shows, XG regulatory system can readily accommodate the rapid evolution of shared understandings of technical and political feasibility, while market-based systems depend on clear and stable goals (or predictably adjusted) so that traders can optimize their behavior by responding to changing prices.

Conclusion

Both the Montreal Protocol and CARB succeeded because of the way they institutionalize the mutual correction of political interest and practical problem solving. Political interest and the incentives it generates are indispensable in both cases. But the interest in solving an environmental problem at acceptable cost, alone, would have been ineffectually blind but for the guidance it received from practical learning, just as the practical efforts would have been impotent but for the political interests that lent strength to their purpose. In both cases this mutual correction depended on promoting exploration and experiment to resolve or reduce uncertainties; adjusting regulatory goals in light of that experience—and then repeating this learning cycle. In both cases, the institutions also marshaled information to address political counter-movements—for example, industrial groups opposed to eliminating ODS for which there were no viable alternatives or car manufacturers unwilling to commit to build electric cars until batteries and other critical technologies were demonstrably mature.

In practice the SO_2 regime teaches the related lesson that collaboration, often with public facilitation, and market mechanisms are often complements, not

[88] Indeed, studies of patenting data show that during the era of "command and control" regulation there was a much higher level of innovation in sulfur control than during the market period (Taylor, Rubin, and Hounshell 2003).

substitutes. Cap-and-trade regimes and other market incentives can be highly effective at yielding static efficiency. But whether they are part of dynamic efficiency—that is, deep transformations of industrial practices that involve radically new technologies, fuels and behaviors—depends on many factors that the market, itself, does not supply. The US SO_2 system is one of the most well established and best run cap-and-trade regimes in the world; a close look at that history showed that the most profound developments of new technologies as well as access to new fuels occurred outside (and mostly before) the establishment of the market. Scrubbers, in particular, were pivotal—and their success depended on collaboration among firms and various independent entities on experimentalist lines.

Our central point in this chapter is that XG processes are much more ubiquitous in environmental governance at all levels—from the global to the local—than originally understood. These systems are most important when policy makers, firms and other interest groups broadly agree on the need for a transformation in industrial activity but don't know how to achieve that outcome. The standard wisdom about how to solve such problems—integrated global treaties, independent aggressive regulators, and the utilization of markets wherever possible—have offered misleading guides to the varied efforts to address the problem of global climate change ignores the real history of important successes..

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