13 Towards an effective system of monitoring, reporting, and verification

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Information is essential to assessing policies, but information may also be costly. This chapter discusses information systems for monitoring, reporting and verification (MRV) of climate change policy. It enumerates six essential roles for MRV: (1) assessing the performance of national policies, (2) comparing across national efforts (and thereby bolstering credibility and mutual confidence to reduce free riding), (3) assessing aggregate international action towards global goals, (4) evaluating alternative policy instrument designs, (5) facilitating cross-national linking, and (6) enabling adaptive learning. The diversity of national pledges now emerging in the international climate regime only heightens the need for MRV. The chapter argues that even if national policies are diverse and targeted, MRV should cover a broad scope of policies and outcomes to ensure comprehensive impact assessment, while keeping costs low to ensure net benefits, to attract participation, and to avoid discouraging ambition.

1 Introduction

Information is essential to good policy (Mackaay 1982). We need to know whether policies are making a difference, how much, and in what ways compared to relevant alternatives. Successful environmental policy, in particular, depends on good information about the extent of problems and about the relative performance of

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alternative policy measures (Esty 2004). Information can enhance policy performance and public accountability. Around the world, countries are increasingly adopting systems to monitor and evaluate information for both prospective policy assessment and retrospective policy evaluation (Wiener 2013).

Information can itself be used as a policy instrument, when rules mandate information disclosure by governments or businesses in order to foster accountability through public awareness of actions and outcomes, and to motivate actors to ensure their compliance and enhance their ambition. As Jeremy Bentham posited, 'the more strictly we are watched, the better we behave' (Bentham 1796). Careful empirical studies show that well-designed information disclosure policies can spur actors facing disclosure (and concerned about their reputations) to make even greater reductions in pollution than required by direct regulation (Bennear and Olmstead 2008).

At the same time, however, information can be costly, both in the direct expenses for its production (hence the calls to relieve administrative burden, reduce paperwork, and cut red tape), and in the inhibitions that disclosure may impinge on autonomy and decision making (hence the calls to shield privacy and deliberation) (Schauer 2011). There can be tradeoffs among the benefits and costs of expanded information requirements. The cost of information can distort choices when some actors have more information than others (Stiglitz 2000), and too little information can impede choices and the evaluation of policy measures. But excessive information disclosure can also be undesirable, overwhelming and confusing decision makers (Ben-Shahar and Schneider 2014).

Optimal information policy seeks to reconcile these tradeoffs (Mackaay 1982: 110, Ogus 1992: 116). It does so by designing reporting protocols and selecting metrics that are accurate and comprehensive, by generating useful indicators, and by targeting audiences who can use them well, yet without imposing excessive costs, encouraging evasion, or overloading recipients with too much information (Weil et al. 2006, Ben-Shahar and Schneider 2014).

Further, if the costs of information are borne by private actors or by countries while the benefits of information are widely shared, then information itself – like climate protection – will have the character of a public good, with incentives for actors (firms or national governments) to underinvest in providing such goods while free riding on others' provision (Barrett 2003). If this is significant, then information can require some form of collective action, such as an international agreement to collect, share and check – i.e. to monitor, report and verify.

2 Challenges facing information for climate change policy

For climate change policy, good information policy is more crucial than ever. A well-designed system of monitoring, reporting and verification (MRV) will be essential to the success of the evolving international climate regime (Aldy 2014, Bellassen and Stephan 2015). To succeed, a system of MRV will need to be designed in a way that enhances the benefits and reduces the costs of this information.

After two decades, the 1992 United Nations Framework Convention on Climate Change (UNFCCC) is entering a new phase. The 1997 Kyoto Protocol to the UNFCCC had sought agreement on quantitative emissions limitation targets, applicable to 'Annex I countries' (generally, although not all, wealthier countries), leaving to each country the choice of measures to achieve its national target; but Kyoto provided no quantitative targets for 'Non-Annex I countries' (generally, although not all, lower-income countries). Some key Annex I countries did not join Kyoto's targets (e.g. the US, at the time the world's largest national emitter and now the second largest), and some key Non-Annex I countries soon became much larger emitters (e.g. China, now the world's largest national emitter).

The IPCC reports that Annex I countries, as a group, actually met their aggregate targets in both the UNFCCC (reducing their aggregate emissions below 1990 levels by 2000 – partly due to the economic downturn in former Soviet countries) and in the Kyoto Protocol (reducing their aggregate emissions more than 5.2% below 1990 levels by 2012) (Stavins et al. 2014, Section 13.13.1.1, pp. 59-60). But these emissions reductions by the group of Annex I countries under the UNFCCC and Kyoto Protocol did not succeed in reducing *global* emissions, because rapid increases in emissions from Non-Annex I countries (major developing countries) drove overall growth in global emissions over the past two decades (Stavins et al. 2014, Section 13.13.1.1, p. 60).

After important talks since 2009 in Copenhagen, Cancun, Durban, and Lima, negotiations in Paris in December 2015 will seek to launch a new phase of the UNFCCC for the year 2020 and beyond. This new regime is calling on each country to propose its own 'Intended Nationally Determined Contribution' (INDC), to be melded into a global effort and reviewed (and updated) over time. As under Kyoto, countries may choose their own sets of measures to reduce their emissions of various greenhouse gases (GHGs) in various economic sectors – such as energy and electricity, transportation, agriculture, and forests – and using various policy instruments – such as technical standards, performance standards, taxes, allowance trading markets (both within and across countries), reducing subsidies, and adaptation measures, among others. But unlike Kyoto, the INDC approach now enables countries to aim their actions at, and report their results against, differing baselines, differing targets, and differing time periods. Also unlike the targets under Kyoto, the call to adopt INDCs now applies to all countries. The regime of INDCs is expected to enable each country to choose its own level of ambition according to its national circumstances, and to offer financial assistance from wealthier to poorer countries.

The flexibility for each country to design its own INDC may attract wider participation, which is important to address global emissions and global impacts effectively. (Incomplete participation would leave key sources of emissions unaddressed and may also lead to cross-country leakage of emitting activities, thus undermining the environmental effectiveness of the incomplete regime.) But the INDC approach may also invite free riding if countries pledge to do little more than they would have done anyway (Barrett 2003). Assessing and comparing efforts across these differing INDCs will be challenging (see the chapter by Aldy and Pizer in this book). Countries may formulate INDCs with differing scopes (e.g. gases, sectors), differing timing (e.g. base year, target year), differing targets (e.g. reductions below emissions in a past base year, reductions below a projection of future business as usual (BAU) emissions, or peak emissions to occur in a future year), and differing units of measurement (e.g. total emissions or emissions per unit of economic activity), all of which will complicate efforts to ascertain what these policies are pledging to achieve, what they actually achieve, how they compare with each other, and how they add up to yield global outcomes. Countries could potentially choose INDC metrics that are difficult to verify (such as reductions below BAU, which is a model projection), or that mask low ambition and free riding. Countries might adopt measures to limit emissions but also simultaneously adopt other domestic policies to subsidise their industries or otherwise 'cushion' the economic burden of the emissions limitation measures, thus undermining their actual emissions reductions in ways that may be difficult for outsiders to monitor and verify (Wiener 1999, coining the term 'fiscal cushioning', Rohling and Ohndorf 2012).

Many countries already have their own domestic MRV systems. Examples include the US GHG Reporting Rule and the reporting under the EU Emissions Trading System (Smith 2012). Countries might also act together in 'plurilateral' groups (Stewart, Wiener and Sands 1996, Stewart and Wiener 2003) or 'clubs' (Stewart et al. 2013, 2015, Nordhaus 2015, Keohane et al. 2015), requiring some form of MRV to document the collective actions of the group.

3 Key roles of MRV in climate policy

Any climate policy will need MRV to assess its effectiveness and impacts. The flexibility of the INDC process, and the diversity of the terms of potential INDCs and club initiatives, increase the need for, but also the challenges to, a well-designed system of MRV (Stewart et al. 2013: 384-391).

MRV of climate policies will be crucial for at least six roles, including:

a. *Measuring the actual performance of countries' implementation of their INDCs towards their own stated goals over time*. If a country or a club pledges to achieve something by a certain date, how will others know if that pledge has been accomplished? How will the country or club itself know what it has accomplished? What will the 'review' stage of 'pledge and review' actually examine? MRV is essential to tracking these results and ensuring policy accountability.

b. *Comparing efforts and results across countries*. Actors will want to know how well different jurisdictions are achieving their pledges compared to other jurisdictions. As Aldy (2014) and Aldy and Pizer (2014, 2015) detail, MRV is needed to produce and check the information from 'policy surveillance' to compare national or club efforts. This comparison may also encourage the level of ambition of each country or club – knowing what others are doing may build the confidence of each actor in the credibility of others' efforts, and thereby attract participation, compliance, and ambition (Barrett 2003).

c. *Comparing the performance of different policy designs and instruments*. Policies should be compared in terms of their efficacy (such as reducing GHG emissions), costs (direct industry compliance costs and broader social opportunity costs), and ancillary impacts (both co-benefits and countervailing harms in other environmental, social and economic outcomes) (Wiener 1995, Shindell 2015). For example, reducing emissions from deforestation may also affect biodiversity and local human populations; switching from coal to gas or nuclear may reduce CO2 emissions and also reduce other conventional air pollutants, yet also increase other risks; solar and wind energy may affect biodiversity; biofuel production may affect deforestation and food prices; and so on. This comparison of policy design and performance goes beyond comparing overall national efforts to examining at a more detailed scale the cost-effectiveness or cost-benefit evaluation of different policy options deployed within countries. Evaluating a comprehensive set of policy impacts follows from UNFCCC Article 4(1)(f), which calls for impact assessment of mitigation policies. Sharing this learning across countries can foster international diffusion of improved policy designs (Wiener 2013). Still, as Aldy and Pizer (2014, 2015) discuss, different methods for comparing differing national measures will involve different criteria, and no single comparison method will fully satisfy all criteria. Aldy (2014: 282) notes that there can be a choice between comparing efforts and comparing outcomes, each of which has its pros and cons. Ideally, MRV would cover both efforts and outcomes, in order to test the relationship of policy design to outcomes and thereby help states select the best policy designs for future use. Testing actual policy performance requires broad MRV covering both the specific policy and associated data on other variables that might also be influencing the outcomes that seemed to be due to the policy, such as other social trends and other public policies.

d. *Aggregating the sum of countries' progress towards global climate protection objectives*. For example, in order to assess how likely aggregate measures will be to limit global average surface warming to no more than 2°C above pre-industrial temperatures, or whatever other overall goal(s) may be selected, MRV will be needed to collect and check data for each jurisdiction and combine these data on a common metric.

e. *Facilitating cross-country connections*. For example:

- Linking of emissions trading markets across countries or clubs could employ MRV (using common metrics) to track trades and ensure that allowance transfers represent real emissions reductions that satisfy emissions limits in the buyer's jurisdiction (Stewart et al. 1996, Wiener 1999, Stewart et al. 2013, Bodansky et al. 2014, Keohane et al. 2015; see also the chapter by Stavins in this book). In the same way, common MRV can facilitate trading across the member states of a multi-state union – such as the EU or the US – or a plurilateral club. Common MRV coupled with recognition of allowances or credits from other states adhering to such common MRV can enable states to opt in to multi-state trading without formally agreeing to link their markets (as proposed by Monast et al. 2015, and facilitated by US EPA in its Clean Power Plan final rule issued in August 2015).
- An international carbon tax (or coordinated national carbon taxes) (see the chapter by Wang and Murisic in this book) would need MRV of emissions to ensure compliance with the tax, and to test its efficacy in reducing emissions. An emissions tax may be more susceptible than a quantity-based approach to fiscal cushioning in ways that are difficult to monitor and verify (Wiener 1999, Rohling and Ohndorf 2012). But the general point is that, whichever instrument is employed to limit emissions, MRV will need to include attention to other policies as well in order to assess the overall impact. Here, climate MRV may draw lessons from other efforts to assess overall fiscal policies, such as IMF assessments of macroeconomic stability.
- Matching international financial and technical assistance to where it is most needed or most effective will require MRV to measure the results of such assistance (Carraro and Massetti 2012).
- If countries adopt border trade adjustments that seek to treat the emissions embedded in imports in a way that is similar (non-discriminatory) to emissions from domestic production (such as a border carbon tax, or a border allowance requirement, on imports) (Nordhaus 2015, see also the chapter by Fischer in

this book), then MRV will be required to assess the emissions policies adopted by the source country of the imports (i.e. the exporting country) to calibrate the magnitude of the border trade adjustment in the importing country.

f. *Fostering adaptive updating of policies and MRV methods over time*. By measuring the actual performance of climate policies, MRV can enable retrospective and repeated performance evaluation, that is, evidence-based decision making that supports planned adaptive policy revision over time (McCray et al. 2010). Further, MRV methods are not static or exogenous; designing policies to reward dynamic advances in approaches to MRV (such as by setting default emissions factors but inviting sources to seek more abatement credit if they demonstrate more accurate MRV) can promote adaptive improvement over time in the MRV methods themselves (Wiener 1994, Aldy 2014: 281, 283, 289).

4 Improving MRV for climate policy

MRV has been addressed in past climate agreements, such as the national communications and emissions inventories under the UNFCCC. But this MRV system remains incomplete, with still patchy monitoring of different sources, sectors and gases, sporadic reporting by different sets of countries, and inconsistent verification by different types of auditors at different scales (national, firm, project site) with different payment contracts (Aldy 2014: 285-288, Bellassen and Stephan 2015). Data remain uncertain for some types of sources or countries, and marginal investment in MRV does not always correspond to the marginal value of information (or ‘materiality’, see Bellassen et al. 2015). At the same time, in some MRV protocols, the cost per tonne of emissions is already quite low, offering grounds for optimism that improved MRV can be implemented without undue cost (Bellassen and Stephan 2015, Bellassen et al. 2015).

Some past international agreements have developed effective MRV, such as for arms control and nuclear non-proliferation (Ausubel and Victor 1992). These regimes offer some lessons for climate policy. Arms control agreements call on states to regulate themselves (or their military forces), whereas international climate agreements call on states to regulate private subnational and transnational actors, which may make MRV more complicated for climate (Ausubel and Victor 1992). Further, the perceived high national benefits of arms control and non-proliferation have justified major investments in MRV, whereas the incentive to invest in MRV for shared global climate benefits may be weaker. On the other hand, climate MRV could be easier to the extent that emissions limitations policies can be monitored over years whereas arms control and non-proliferation accords require immediate or very rapid detection of non-compliance. To be sure, arms control and non-proliferation accords have not always succeeded, and indeed some such agreements have been rejected when their MRV systems failed to satisfy critics. For example, the Comprehensive Test Ban Treaty (CTBT) faced objections that underground testing might be difficult to monitor, and the 2015 nuclear non-proliferation accord with Iran faces acute debate over the likely efficacy of its MRV provisions, including limits on immediate inspections by the International Atomic Energy Agency (IAEA) (on this debate over MRV, see Welsh 2015).

Successful arms control and non-proliferation agreements have often relied on a combination of MRV strategies, including not only national reporting (which other parties may not find credible) but also on-site inspections (including unannounced in-country inspections by expert teams), visible indicators of non-compliance, and verification via remote sensing with ‘national technical means’ such as satellites (Ausubel and Victor 1992). Remote sensing by satellites (sometimes supplemented by telescopes or *in situ* sensors) can monitor changes in land use and forest cover (GFOI 2014). Remote sensing could also detect the status of key facilities and technologies, such as carbon capture and storage (CCS) projects, adaptation infrastructure, and geoengineering projects. But such remote sensing will still require on-site observers to verify actual changes, and even reporting the installation of specific technologies will still require corroboration to verify that the technology is operating and actually reducing emissions or damages (as illustrated in the recent scandal of VW diesel engines that were designed to limit emissions in the laboratory but then increase emissions on the road). Satellites will soon monitor GHG emissions fluxes from countries – NASA’s Orbiting Carbon Observatory 2 (OCO-2), launched in July 2014, ‘will be collecting space-based global measurements of atmospheric CO_2 with the precision, resolution, and coverage needed to characterize sources and sinks on regional scales’ (NASA 2015), and its OCO-3 will be launched in late 2016.[2] Fisheries management agreements have also employed satellite and on-board 'vessel monitoring systems', both to track vessel movements and to monitor fish catches. Similarly, climate MRV can employ both satellite sensing and on-site inspections, with audits by neutral third parties (such as auditing firms, environmental non-profit organisations or intergovernmental organisations).

As discussed above, information has both benefits and costs. Seeking more accurate and comprehensive MRV may foster transparency, accountability and comparability. It may improve credibility and mutual confidence and thereby attract participation. It may enable assessment, aggregation, comparison, policy design evaluation, cross-country connections, and adaptive learning. But making MRV more accurate or comprehensive may also raise its cost. In some cases, broadening the scope is net beneficial – through expanding target benefits in reduced GHG emissions, promoting co-benefits in air quality, and avoiding perverse countervailing risks from other gases or substitute technologies (Wiener 1995, Shindell et al. 2012, Shindell 2015), as well as by achieving economies of scale in broader applications of the same MRV methods across more sources and transactions (Bellassen et al. 2015). But in other cases a broader scope may yield only minor gains in coverage at high cost – such as lowering the reporting threshold to cover small facilities (Bellassen et al. 2015: 324-325). Estimating emissions factors may be a lower-cost approach to small emitters (McAllister 2010). Costly MRV may not only yield smaller net benefits, but may also lead countries to evade reporting or to reduce the ambition of their pledges in anticipation of costly accountability.

The new climate regime can make progress by designing MRV provisions that collect needed and accurate data in ways that countries find acceptable and even attractive. Burdensome MRV may deter participation and ambition; low-cost but effective MRV may encourage participation and ambition. Design elements for low-cost but effective MRV might include, among others, international financial assistance for monitoring and reporting (Aldy 2014: 284, 290); regular national reporting using shared international MRV guidelines and reporting protocols; standardised BAU projections from joint expert modelling exercises; on-site inspections by joint expert teams; remote sensing of

2 See https://en.wikipedia.org/wiki/Orbiting_Carbon_Observatory.

sources, sinks and emissions fluxes (e.g. from energy emissions, transport emissions, process emissions, and land use change and forests/REDD+) (Esty 2004: 156, 177); and independent verification auditors, paid by neutral funds such as the UNFCCC, another UN body, the GEF, World Bank, or other MRV fund (not paid by the countries or actors being audited, because that may create a conflict of interest leading auditors to overstate achievements, as seen in securities market ratings agencies). Data about emissions and policy impacts should be translated even-handedly into comparable metrics of performance to facilitate comparison, aggregation, policy design evaluation, and adaptive updating. Learning about methods of MRV should be shared across countries, perhaps through neutral clearinghouses. Lower-income countries may need financial assistance to implement effective MRV, and higher-income countries may see such financing as mutually beneficial because better MRV can help reduce emissions globally, bolster confidence and reduce free riding, detect and avoid leakage, and facilitate linking.

The scope of MRV – what it measures and hence what data must be tracked – should be calibrated to maximise its net benefits. A more comprehensive scope gives a more complete impact assessment, but also requires more information and analysis; a more narrow scope reduces the information and analysis costs, but may also neglect or even encourage unintended consequences that undermine larger objectives (Wiener 1995). To be fully comprehensive (a criterion highlighted in UNFCCC Art. 3(3)), the scope of MRV should cover all relevant climate policies – not only the mitigation options selected in each INDC, but all GHGs in all sectors (including those targeted by the INDC as well as others not yet targeted but potentially still affecting the climate), sinks (such as forests/REDD+), co-benefits (such as air quality and public health, because they may motivate participation and ambition by all countries and notably by developing countries) (Shindell et al. 2012, Shindell 2015), countervailing risks (to avoid adverse side effects, see Wiener 1995, as indicated in UNFCCC Art. 4(1)(f)), and costs (to enable policy design comparisons). And it should cover all countries – even those not adopting (ambitious) INDCs – in order to monitor and prevent leakage of emissions from regulated to less regulated countries.

Fully comprehensive MRV should also cover other climate policies being undertaken beyond emissions limits, such as technology R&D, financing, adaptation, and geoengineering (solar radiation management, or SRM). Adaptation may be largely motivated by its local benefits, but international reporting on adaptation can share learning on best practices across jurisdictions, and can help match international adaptation funding to demonstrated results. Reporting on SRM research projects could be crucial to enabling international learning about the pros and cons of SRM options (Keith et al. 2010) and to preventing unwise deployment of risky SRM projects (Stavins et al. 2014, Section 13.4.4). Unlike emissions limits which confront incentives to free ride and avoid effort, SRM may conversely confront incentives to be a unilateral first mover; as a result, international cooperation may seek to restrain hasty SRM, and MRV of SRM may thus be more akin to MRV for arms control and non-proliferation (Stavins et al. 2014, Section 13.4.4; see also the chapter by Barrett and Moreno-Cruz in this book). Compared to MRV of emissions reductions, MRV of SRM geoengineering efforts may require greater emphasis on rapid real-time warnings through remote sensing, and verification through on-site inspections.

Where measurement is currently uncertain (as for some sectors, see Bellassen et al. 2015), that is not itself a reason to ignore or deny credit to emissions reduction efforts in those sectors. Rather, measurement uncertainty calls for adaptive policies that reward dynamic advances in MRV methods, such as by calibrating the degree of credit to the demonstrated accuracy of MRV, thereby creating an incentive for actors to improve MRV methods and reduce measurement uncertainties (Wiener 1994). In this sense, MRV is not static or exogenous, but rather endogenous: improvements in MRV methods depend on the incentives provided in climate policies.

5 Conclusion

The new climate regime is not a single treaty, but a complex of multiple agreements, INDCs, clubs, and transnational networks (Keohane and Victor 2011, Stewart et al. 2013, Stavins et al. 2014, Sections 13.3-13.4; see also the chapters by Keohane and Victor, and Stewart et al. in this book). Hence, comprehensive MRV should cover climate measures under not only the UNFCCC, but also other international agreements that bear on climate, such as GHG limits under the Montreal Protocol, the international aviation agreement (ICAO), and the network of low-carbon cities, among others (Stewart et al. 2013).

What we measure strongly shapes what we manage. The prospect of MRV (including its scope and cost) will have an important role in shaping the climate policies that countries adopt and implement. In turn, the system for MRV will be shaped by its benefits and costs, and by its ability to attract participation of key countries – for example, by keeping costs low, and by highlighting local co-benefits such as air quality and adaptation.

After COP21 in Paris, even if the climate policy regime is a complex of diverse and fragmented national commitments and institutions, it will be desirable to construct a comprehensive MRV system that embraces the multiple components and actors of the regime complex for climate. MRV itself is likely to be less costly than measures to limit emissions (especially if broadly applied to achieve economies of scale), and indeed can increase the net benefits of such measures. Investing in well-designed comprehensive MRV will likely be worth the costs, especially compared to adopting policy measures to limit emissions and realising only later that weak or absent MRV means that we know little about what those (costly) measures actually accomplished. A comprehensive MRV system would broadly cover all the gases, sectors and impacts noted above. Comprehensive MRV would promote the key functions of assessing and comparing national policies, aggregating global efforts, evaluating policy designs, facilitating linking, and promoting adaptive learning. To keep costs low and engage innovative public-private partnerships, components of this broad MRV system could be undertaken by different actors, such as intergovernmental organisations, national governments, auditing firms, university researchers, non-profit organisations, and private businesses. Designing MRV to cover co-benefits, countervailing risks, and adaptation, and to foster financing and allowance trading links, as noted above, could help shape socially desirable policies and offer added incentives for participation by low-income as well as wealthy countries. MRV of SRM geoengineering projects will be important for learning, and for restraining hasty deployment posing adverse side effects. Altogether, a comprehensive MRV system would provide the information essential to assessing and enhancing the success of the climate regime.

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About the author

Jonathan Wiener is the Perkins Professor of Law, Environmental Policy and Public Policy at Duke University. He is also a University Fellow of Resources for the Future (RFF). He served as President of the Society for Risk Analysis (SRA) in 2008, and co-chair of the World Congress on Risk in 2012. He is a member of the scientific committee of the International Risk Governance Council (IRGC). He has been a visiting professor at Harvard, the University of Chicago, Univ. Paris-Dauphine, Univ. Paris-Ouest Nanterre, Sciences Po, and EHESS in Paris. He was a co-author of the IPCC, Fifth Assessment Report, Working Group III, chapter 13 on “International Cooperation” (2014). His publications include the books *Risk vs. Risk* (1995, with John Graham), *Reconstructing Climate Policy* (2003, with Richard Stewart), *The Reality of Precaution: Comparing Risk Regulation in the US and Europe* (2011, with others), and *Policy Shock* (forthcoming, with others). Before coming to Duke in 1994, he served at the US Department of Justice, Environment and Natural Resources Division (DOJ/ENRD); at the White House Office of Science and Technology Policy (OSTP); and at the White House Council of Economic Advisers (CEA); there he helped draft the IPCC 1st Assessment Report (1990), helped negotiate the Framework Convention on Climate Change (FCCC) (1990-92), and helped draft Executive Order 12,866 on regulatory review (1993). He was a law clerk to federal judges Stephen G. Breyer (1988-89) and Jack B. Weinstein (1987-88). He received his J.D. (1987) and A.B. (1984, Economics) from Harvard University.