Policymaking as Design in Complex Systems—The International Climate Change Regime

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This paper explores policymaking as a design process in complex systems using the example of the international climate policy regime. Applying Johnson's (2008) framework on science and the designing of policy for complex futures, we establish that the evolution of international climate policy displays some characteristics of an ad hoc complexity-science policy-design process. The IPCC's emissions scenario approach is used as an example of the current climate-science policy regime's approach to dealing with policy uncertainty. We conclude that such an approach fails to capture the true relationships between policymakers, the complex models they seek to design and the actual uncertainty inherent in the environment. Further, we conclude that more formal linkages between climate policymaking and complex systems science could generate valuable new insights for both policymakers and scientists.

Introduction

The emerging regime of international climate policy is a global-scale real-time experiment in handling complex, interrelated and emergent factors spanning environmental, economic and social change. The formulation of climate policy is a century-scale sequential design process under uncertainty. In it we see a classic example of the coevolution of problem and solution through incremental advances in scientific understanding, coupled to political responses and changes of behavior. This paper explores the international climate policy regime from the perspective of policy making, framed as a design process informed by complex systems science.

Policymaking and Complexity

A Complexity Framework for Policy Making

Johnson (2008) argues that design, policy and complex models are closely entwined in real-world policy processes and sets out a framework for thinking about how decision making taking complexity into account differs from the traditional scientific method based on point predictions of the future. In this framework, the policy design process is characterized by a number of elements:

1. Design begins with political commitment to address the problem in the form of perceived needs/requirements and attempts to generate new approaches to satisfy those needs/requirements;
2. Acceptable solutions to what are often multiple constraint optimizations are sought;
3. These potential solutions are evaluated;
4. During the generation and evaluation of solutions, the problem definition may be transformed;
5. The design process initially generates a multilevel hypothesized representation of the new policy at high levels of abstraction;
6. Eventually a more precise statement of what the final approach will be and how it will be implemented emerges; a policy blueprint.

In the domain of international climate change policymaking we can observe this process at work at these various levels/stages—from the highest level formulation and negotiation of the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto protocol, to more specific design processes around, for example, the clean development mechanism and emissions trading schemes.

We will now use Johnson's framework to reflect on current international climate

change policy and explore whether this perspective helps to make sense of current practice.

Applying the Framework

Establishing Commitment, Elaborating Needs/ Requirements

Global commitment to addressing the problem of climate change was established with the adoption of the UNFCCC at the Earth Summit in Rio de Janeiro in 1992. The objective of the UNFCCC is contained in its Article 2 as follows:

The ultimate objective of this Convention…. is to achieve…. stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner. (UNFCCC, Article 2)

Article 2 is the highest level design brief/requirement guiding the evolving architecture of the international climate policy regime. As an over-arching statement of requirements Article 2 is highly abstract and leaves a great deal of work to be done to explore, agree and translate those requirements into plans of action. In particular, there is need to establish and accept globally:

- What should be the stabilization level for greenhouse gases to prevent 'dangerous anthropogenic interference'?
- How soon should this be achieved?

Multiple Design Constraints in the Climate Regime

There is clear evidence of multiple design constraints in the climate regime that leads to colorful, political exchanges within the negotiations; once again, article 2 is a good example. It seeks (a) to avoid dangerous anthropogenic interference, (b) to do so on meaningful timeframes for ecosystems and (c) to enable sustainable economic development. These are complex and multi-faceted goals which potentially conflict.

Considered as a whole, the myriad texts of the UNFCCC regime, including Kyoto Protocol, are essentially a complex design brief containing hundreds of often competing constraints. Some of the most striking are contained in Articles 3 (Principles) and 4 (Commitments). These include, for example:

The Parties should protect the climate system for the benefit of present and future generations of humankind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities (Article 3.1).

Weighing up present and future benefits and costs is fraught with methodological difficulty. The furor in policy circles over the very low discount rate used in the Stern Review of the economics of climate change (Stern, 2006; Nordhaus, 2007) is a very clear example (Hulme, 2009). Equally, the notion of 'common but differentiated responsibilities' is a source of great conflict and tension that lies at the heart of current disputes about equitable responses to climate change. Another example is:

The Parties have a right to, and should, promote sustainable development (Article 3.4).

There are few detailed operational agreements in place as to what constitutes a pathway for sustainable development (the Millennium Development Goals are a notable exception) which has three design goals/constraints: economic, social and environmental.

Potential Solutions are Generated and Evaluated

The UNFCCC is a 'living agreement' in that it has clauses that allow for revisions. Article 4.2b of the UNFCCC requests developed countries to return, individually or jointly, emissions of carbon dioxide and other greenhouse gases to their 1990 levels—but without mention of a specific time frame. Shortly after the

UNFCCC entered into legal force, a new process was launched to strengthen commitments to reduce greenhouse gases beyond the year 2000. This was known as the Berlin Mandate and led to the creation of the Kyoto Protocol to the UNFCCC.

The Kyoto Protocol was adopted at the end of 1997 and entered into force in 2005. It fulfilled the requirements of the Berlin Mandate and published quantified legally-binding emissions targets for developing countries to be achieved by 2012. Interestingly, it took eight years from agreement to entry into force because nations had to elaborate a large number of specific rules and modalities (what constitutes the definition of a 'tree'; how exactly would new 'mechanisms' work such as the clean development mechanism and emissions trading schemes).

COP 15 in Copenhagen in 2009 was part of the ongoing second major revision of the evolution of the design brief/requirements under the UNFCCC. It was a re-evaluation of the requirements of Article 2 given (a) new scientific understanding such as that contained in the IPCC's Fourth Assessment Report (AR4) published in 2007 (IPCC, 2007a, 2007b, 2007c) and (b) new global political understandings emerging from this scientific evidence (e.g., Stern 2008).

So potential solutions have indeed been generated and evaluated and re-worked and those solutions remain complex, difficult to pin down and ambiguous.

Transformation of Problem Definition

Overall, in nearly two decades, it could be argued that the design of the response to climate change has changed relatively little. Short-term targets have been set and missed, medium-term targets have been set and met by some, but missed by others; and a longer-term set of policy goals is slowly emerging, based on a risk approach to future global temperature increase. Since this is our one-and-only experiment in designing a climate policy response, there is no obvious objective measure of the speed with which this is being achieved; however, there is evidence the process is accelerating. The two year negotiations leading up to Copenhagen Accord accomplished a great deal more that had been achieved in the previous decade.

During the first seventeen years of the climate change regime the definition of the problem has undergone considerable transformation from a focus on emissions targets to an agreement to limit global temperature increase.

Initially the emphasis was characterized by a focus on emissions targets for developing countries—specific targets to be met on certain dates (e.g., developed countries to return their emissions to 1990 levels by the year 2000 in the UNFCCC). Recognition that the emphasis should be on emissions 'pathways' rather than specific yearly 'check points' led to the quinquennial approach adopted in the Kyoto Protocol, over a longer time frame.

Around 2005, the world's science community focussed on and elaborated the scientific interpretation of the phrase 'dangerous anthropogenic interference' (DAI) in Article 2. The outcome was an injection into the policy process of probabilistic assessments of the likelihood of achieving temperature targets according to different sets of potential emissions pathways (Schneider & Mastrandrea, 2005; Schellnhuber *et al*., 2006).

The goal of limiting global temperature increases to 2°C by the early peaking of global emissions and their reduction by 50-80% by 2050 (compared approximately with today) contained in the 2009 Copenhagen Accord represents a significant transformation of the problem definition. It exposes multiple competing design constraints (fossil fuel energy use for development versus greenhouse gas emissions reductions) in the regime and recasts working policy time-frames from Kyoto's rolling five year plans to a new forty year time horizon.

The problem is transformed from negotiation about leadership and how quickly developed countries can 'turn off the emission tap' into what is requisite to meet the global 2°C design constraint.

Representation of the New Approach at High Levels of Abstraction

At its highest level, the UNFCCC represents a model of relationship between human activity and the earth's climate system. In this model there is the recognition that humans are a subcomponent of a complex system and that we are exerting a significant impact on the system. Classic visual expressions of this abstraction are the carbon cycle models and basic functional outlines of global climate change Integrated Assessment Models (IAMs). Under the UNFCCC, great methodological strides have been achieved in representing and accounting for anthropogenic greenhouse gas emissions. Quantities of fuel (e.g., wood, coal) have been trackable to some extent for over a century, but systematic meaningful emissions accounting across a range of fuels and other sources of greenhouse gases (agriculture, waste, industry) is a relatively new capability. The abstract carbon cycle is now embodied in greater detail in the framework of greenhouse gas inventories. In theory, every real tonne of greenhouse gas emissions—whether it be from a car, a power station, a ruminant animal or the decay of flat-pack furniture dumped into a landfill—is now observable to policymakers.

However, socio-technical systems are much more than flows of carbon; the flow of carbon is merely one level of understanding. Other levels are necessary to describe the system—such as human activity, its drivers and its consequences. Embodied in the high-level abstraction is the understanding that humans can identify and isolate their impact, manage it, and that in turn the climate system can be managed. The notion that we can manage the system is so deeply rooted in the mind set of policymakers that it is invisible; it rarely surfaces as an assumption. However, the nature and scale of the complexity of the climate system is such that we may already be nearing new states that make this assumption less valid—we may be near to tipping into irreversible climate change (e.g., Lenton, 2008; Lovelock 2006).

Final System Design—Towards a Climate Policy Blueprint?

We have no previous experience in managing century-scale planetary climate change and we are probably at least a quarter of a century away from any kind of 'policy blueprint'; that is, a precise statement of what the final new system state should be. By 2100 we will have this experience. We will spend this century on the process of climate regime design. Some opinion formers are turning their attention to backcasting, from say 2050, as a way of exploring how we mismanaged/managed the design task in the intervening years. The film, the Age of Stupid (2009), for example, takes a negative approach and explores how we failed to design an appropriate response, whereas Gore (2009) takes a positive approach and writes back from 2050 outlining the decisions we took in order to achieve our goal of having successfully avoided dangerous climate change. This envisioning is an interesting approach to support the development of a policy blueprint.

Does the Complexity Science Framework Add Value?

Using Johnson's framework to reflect on current approaches to the development of climate change policy suggests that it provides a reasonably accurate picture of what has happened in practice. However this is not to say that policymaking has neatly followed the six-step process of sequential designing/decision-making; in reality it has emerged in a much more ad-hoc way over time. For example, as the requirements of the regime were initially proposed in 1992 (e.g., UNFCCC Article 2), the policy makers were busy blueprinting 'solutions'. In the early days these were almost exclusively mitigation policies mainly focussed on cars and power stations. Nearly two decades later, the policy designers have learned to frame problems-solutions in a much wider context. Today there is a growing emphasis on policies to promote adaptation to climate change and a myriad mitigation solutions based on several sectors (industry, domestic, agriculture, transportation) and several greenhouse gases (carbon dioxide, methane, nitrous oxide and others).

There is no doubt that the climate policy regime is a living, learning design regime. It is perhaps a great deal messier than the idealized normative framework proposed by Johnson. However by embracing the core tenets of complexity science, which bring our attention to the inevitability that goals will conflict, that new problems and perspectives will emerge, that policies will need to be re-framed in the light of new evidence and changing circumstances, our future approach to designing climate policymaking could become faster and smarter. In other words, it is better if we embrace and plan for the inevitable complexity of the problem right from the beginning, rather than be surprised by it along the way.

If the climate system is a good example of a complex system (and it is), then there is a strong case that the codesign process of climate policy formulation should be based on a more explicit complexity science perspective. Is there any evidence that this is happening? A key area to consider is how the science-policy process deals with systemic uncertainties in modelling climate futures.

Climate Policy as a Complex Systems Design Process Under Uncertainty

The issue of uncertainty is gradually being made more explicit in approaches to scenarios and modelling of climate outcomes. In this section we give some examples as to how this uncertainty is being expressed and included.

The IPCC's 'Emissions Scenario' Approach

In 2000, the IPCC published a "Special Report on Emissions Scenarios" (SRES). The report took into account several hundred greenhouse gas emissions models projections published in the literature as well as a detailed analysis of 6 well known global emissions models (IPCC, 2000). According to the IPCC:

Future greenhouse gas (GHG) emissions are the product of very complex dynamic systems, determined by driving forces such as demographic development, socioeconomic development, and technological change. Their future evolution is highly uncertain. Scenarios are alternative images of how the future might unfold and are an appropriate tool with which to analyze how driving forces may influence future emission outcomes and to assess the associated uncertainties. They assist in climate change analysis, including climate modeling and the assessment of impacts, adaptation, and mitigation. The possibility that any single emissions path will occur as described in scenarios is highly uncertain. (IPCC, 2000: 3)

The SRES generated a set of scenarios based on differing assumptions about the range of emissions drivers. These were associated with a narrative based on (a) a regional/global emphasis on economic integration and (b) a degree of emphasis on economic/environmental goals.

The IPCC's emissions scenarios have played a critical role in the communication of scientific understanding of future climate change since they were introduced. Different climate modelling teams have been able to run the same emissions scenarios (sets of 'drivers'—population, economic growth, technological characteristics of energy supply system for example) and publish the associated climatological predictions according to their models. Alternative emissions scenarios lead to alternative ranges of temperature predictions—many overlapping each other. In other words, the scientific uncertainty of how much the earth will warm for a given emissions trajectory (scenario) is considerable.

It is important to note that the IPCC's scenario approach treats all SRES emissions scenarios as *equally probable.* The range of uncertainty surrounding future climate prediction is therefore compounded in that it must take into account a broad range of future emissions trajectories from very low to very high.

Discussion: How Effectively is Uncertainty Being Addressed?

The IPCC's scenario approach is a response to the complexity of predicting future greenhouse gas emissions. It is an attempt to simplify the problem for policymakers. However, there are three important features of the IPCC's scenario methodology that are important to note from a

complexity science perspective:

1. The basis of the scenario set is confusing. The IPCC specified 11 points for the SRES writing team in 1997. One of them stated that the new scenarios should "exclude additional initiatives and policies specifically designed to reduce climate change" (IPCC, 2000: 25). In other words the range of scenarios represents 'non-climate-intervention' futures. In practice, humans are likely to adapt in a complex anticipatory way to climate change—due, for example, to increased awareness, increased taxes and costs.
2. The integrity of assumptions on driving forces is questionable. According to the IPCC, 'The ranges over which driving forces vary are large…of these …GDP and population are often exogenous…'(IPCC, 2000: 100). This assumption is completely at odds with scientific evidence that higher temperatures will have negative systemic economic and human health impacts for at least some countries/regions/sectors; in other words, to treat economic and population factors as exogenous is highly questionable.

These scenarios take no account of the link, made by Hulme (2000), for example, between climate assessment and climate outcomes:

Yet it is this reflexive relationship between climate science and wider society that makes the ultimate goal of climate prediction ultimately chimeric—we will never 'know' what future climate will be because the process of estimating future climate alters the very driving forces that shape that climate (Hulme, 2000).

The climate science community's approach (both caused by, and reflected in the work of the IPCC) to modelling socio-economic-technical systems uncertainty has come under increasing scrutiny in recent years (Schenk & Lensink 2007; Smil, 2008; Pielke *et al*., 2008; Schiermeier, 2008; Girod & Flueler, 2009). A new generation of scenarios is emerging in time for the Fifth Assessment Report of the IPCC due to be published in 2013 (Moss *et al*., 2010). A key aim is to speed up the way that scenarios are used in climate assessment. A further aim is to address the criticism of the current approach that alternative combinations of driving forces can lead to similar levels of GHG emissions. While climate analysts continue to focus on emissions, others (e.g., economists, systems scientists) might focus on the driving forces (population, economic output, technologies) and yet others (e.g., biologists) on impacts.

Conclusions

The evolution of the international climate-science policy regime demonstrates some characteristics of Johnson's framework based on considerations of complexity science. There is, for example, evidence of the coevolution of problem/solution within the IPCC-UNFCCC policy process and a growing recognition that the formulation of climate policy is more than sequential decision-making under uncertainty but does in fact require consideration of complex, interrelated, conflicting and emerging goals in light of changing outcomes and priorities. In practice, climate policymaking is indeed reacting to complexity by morphing its decision processes in response to this uncertainty. As new information is gained/generated new waves of subjective judgements around climate change policy analysis reverberate within the system. Some recent examples of science-policy shifts that demonstrate this effect at work include:

- An emerging consensus that a goal of 80% reductions in global GHG emissions by 2050 is necessary to avoid 'dangerous anthropogenic interference';
- A re-imagination of sectoral contributions—recognition of the role of forests, livestock/agriculture/nonCO_2 GHGs—it is no longer all about cars and power stations;
- A recognition of the importance of adaptation—gradually the policy process is assimilating the importance of adapting to climate impacts that we are committed to even in the most optimistic scenario;

- A sophistication of argument around policy menus focussing on unilateral developed country emissions reductions—e.g., the issue of embodied carbon in China's exports;
- A willingness to challenge and incorporate decisions on powerful vested industry interests (e.g., tackling aviation emissions and international marine bunker emissions).

Johnson asserts that the science of complex systems is inextricably entwined with policy and design:

However, policy is, possibly, the only laboratory available to complex systems scientists to make in vivo observations of real complex socio-technical systems. The laboratory is controlled and financed practically by decision makers. The only way for scientists to collect the data they need is to work with policy makers: the science of complex socio-technical systems has no choice but to engage in policy, and to justify its participation by adding value to the design, implementation, management and control of new systems (Johnson, 2008: 521).

Policymakers have yet formally to recognise, embrace and embed complexity science methods in their slow (multi-decadal) *in vivo* experimentation with the climate. The state of scenario analysis (e.g., describing 'non-policy' scenarios) in support of IPCC's review of the climate science literature shows this to be far from the case. To complex systems scientists, the idea of a 'non-intervention climate scenario' is absurd and yet in the world of IPCC climate science it is *all* we have, for now.

On the other hand, sceptical policymakers might observe that there is a naïve innocence about the idea of entwining policymaking with recognition of complexity and uncertainty to design better futures. Ultimately, trying to assume things are more certain than they are is time-wasting and ineffective, as we have seen.

Embracing complexity in climate policy formulation does not have to mean an explosion of uncertainty, the loss of control and the risk to policy 'optimality'. On the contrary it is a way—possibly the only way—to arrive at a realistic solution. Indeed by its nature, a complexity science approach would challenge the idea of a unique 'solution' and certainly the notion of optimality.

Policy based on sound 'science' is a mantra in the climate science-policy community and by 'science' we typically mean ice and mud cores, atmospheric modelling. However, the IPCC's remit also includes the economic, social and human sciences—though it is recognized among climate academics that social scientists are underrepresented in the IPCC (e.g., Hulme, 2009: 98) and the media coverage is heavily biased towards hard 'real' science.

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