Learning and climate change

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Abstract

Learning – i.e. the acquisition of new information that leads to changes in our assessment of uncertainty – plays a prominent role in the international climate policy debate. For example, the view that we should postpone actions until we know more continues to be influential. The latest work on learning and climate change includes new theoretical models, better informed simulations of how learning affects the optimal timing of emissions reductions, analyses of how new information could affect the prospects for reaching and maintaining political agreements and for adapting to climate change, and explorations of how learning could lead us astray rather than closer to the truth. Despite the diversity of this new work, a clear consensus on a central point is that the prospect of learning does not support the postponement of emissions reductions today.

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Introduction

It is now widely recognized that the inclusion of uncertainty is necessary in any analysis of future climate change and response options. There is still much to learn about how climate might change, what its consequences for ecosystems and society would be, and how much it would cost to reduce emissions.

In contrast, there has been far less attention to the learning process itself. How much, and how fast, might we realistically expect to learn about particular elements of the climate change issue? Will new information reduce uncertainties or increase them? How should the expectation of future learning affect today's policy decisions?

Answers to these questions are not merely of academic interest, because despite its relatively sparse treatment in the scientific literature, learning plays a prominent role in the international climate policy debate. The view that we should postpone actions until we know more – one of the motivations for USA's withdrawal from the Kyoto Protocol – continues to be influential, not least because of its intuitive appeal: shouldn't we be able to make better decisions in the future when we have more information?

An interdisciplinary group of climate scientists, economists, demographers and energy analysts recently met to present and consider the latest work on learning and climate change (Conference on Learning and Climate Change, International Institute for Applied Systems Analysis, Laxenburg, Austria, 10–11 April 2006). New theoretical models and better informed simulations of learning are being applied to the question of how learning should affect the timing of emissions reductions. Research is also expanding to engage a wider range of learning-related questions. For example, new information could affect the prospects for reaching and maintaining political agreements on climate change and it will play an important role in the process of adapting to climate change. However, in some cases learning could lead us astray rather than closer to the truth. Despite the diversity of this new work, a clear consensus on a central point emerged from the papers presented: the prospect of learning does not support the postponement of emissions reductions today.

What might we learn?

One set of presentations focused on how learning – i.e. the acquisition of new information that leads to changes in our assessment of uncertainty – is being addressed with respect to the carbon cycle, climate sensitivity, and threshold events. For example, observations of anthropogenic emissions and atmospheric concentrations of CO_2 over the next few decades could allow us to reduce uncertainty in the response of the carbon cycle to emissions over the longer term (Melnikov and O'Neill, 2006). Simulations also suggest that future observations of temperature change and atmospheric composition might narrow substantially the range of uncertainty in climate sensitivity – a crucial property of climate models (Schlesinger and Andronova, 2003). The possibility of anticipating threshold-type impacts is under study, a particularly relevant issue given recent observations of variations in the meridional overturning circulation of the Atlantic Ocean (Bryden et al., 2005) and rapid ice-sheet melting (Thomas et al., 2004; Rapley, 2006; Rignot and Kanagaratnam, 2006).

Most work on learning and economic aspects of the climate issue has focused on the role of various forms of learning-by-doing in models of endogenous technological change and its influence on lowering future mitigation costs. While cost reductions could be substantial (Grubb et al., 2006), they are also highly uncertain, since learning could reduce the costs of both high- and low-emission technologies (Gritsevskyi and Nakicenovic, 2000). The costs of climate change impacts are equally important. These costs are often assessed by comparing conditions under a changed climate with conditions today. But recent work shows that costs may be largely determined by the transition period, when adaptation decisions must be made while agents learn about changing outlooks for future climate.

Incorporating learning in decision analytic models

Understanding the implications of learning about the science and economics of climate change requires incorporating these processes in formal decision analytic models. Early analyses established that the prospect that we will learn more in the future – even if we don't know exactly what we will learn – can affect today's decisions because it increases the value of maintaining options for responding to new information (Arrow and Fisher, 1974; Manne and Richels, 1992; Kolstad, 1996). The more options we have, and the fewer irreversible commitments we have made, the more fully we can take advantage of whatever new information we obtain.

Recent work has also shown that the effect of learning depends in particular on the attitude of the decision-maker towards risk and uncertainty, as well as towards the way in which future generations' preferences are considered. New decision theories can account for uncertainty using imprecise or multiple probability distributions to reflect differences in probabilistic predictions across alternative climate-economy models. Learning can also play a key role in another kind of decision: whether to join, or to remain in, an international environmental agreement.

Historical experience with other global issues also indicates that new models must be adapted to allow for alternative learning trajectories. Those experiences can belie the intuitive expectation that learning will progress uniformly towards reduced uncertainty and towards the true answer over time. For example, the ozone issue provides a classic case of what one of the presentations called 'negative learning', in which uncertainty about stratospheric photochemical processes appeared to decrease from the late 1970s through to the mid-1980s, but predictions of total ozone depletion were actually narrowing in on what turned out to be the wrong answer. The later discovery of the ozone hole pointed to processes missing from the earlier models and substantially increased the projected ozone depletion.

Unanticipated surprises are not unique to the ozone issue. The OPEC–induced supply crisis and the oil price spikes of the 1970s and 1980s made most previous energy projections irrelevant. New projections made in the early 1980s then assumed that high oil prices would be a permanent feature of the energy system, and in a few years were themselves proven incorrect when prices fell sharply in the middle of the decade. Similarly, population projections failed to foresee the rapid decline of fertility in developing countries that began in the late 1960s, and more recently the decline of fertility to very low levels in many industrialized countries.

Why not wait?

Certain aspects of learning discussed above have been incorporated into decision models (e.g. Keller et al., 2004; Dumas and Ha-Duong, 2005). In some cases, the incorporation of learning implies making larger emissions reductions in the near term than would be optimal under uncertainty in the absence of learning. In others, it implies making smaller reductions. But, as the presentations demonstrated, in no case so far examined does the learning effect offset the benefits of near-term emissions reductions entirely.

Learning is a crucial feature of the climate change issue. Analyses of learning can inform research priorities (Keller et al., 2007) by identifying not only which uncertainties in the climate system would, if reduced, yield the largest benefits to today's decisions (Nordhaus and Popp, 1997), but also by identifying the kinds of actions that might be taken to facilitate such learning (Baehr et al., 2007). In some cases, observations of key elements of the system are needed to provide advance warning of potential thresholds or irreversibilities, such as ocean circulation changes, or to keep abreast of rapidly changing situations, such as in population or energy. In others, research is needed that can better resolve uncertainty in fundamental processes, such as terrestrial carbon sinks or the dynamics of ice sheets. Model and theory development may be necessary to avoid misleading learning from flawed models. Because the effect of learning on near-term mitigation decisions depends on the balance between the long-term implications of emissions for the climate system and of emissions reductions for the economic system, analyses that integrate learning about both these effects simultaneously are needed.

Learning also applies to the development of institutions to respond to the climate issue, including international agreements, economic instruments such as tradeable permits or taxes, and legal frameworks to support them (Nordhaus, 2001; Victor et al., 2005). Investing in such institutional development now will allow faster and more flexible policy responses to new information in the future. The same argument applies to new technologies – if we do not invest in different options we may well preclude them.

Regarding mitigation policy, learning can help to improve decisions, not because it is a substitute for emissions reductions now, but because it will help us decide what to do in the future. Reducing emissions now in the face of uncertainty has been likened to taking out insurance against the possibility of unpleasant outcomes (Yohe et al., 2004; Schlesinger et al., 2005). By learning whether the risks we face are likely to be more or less serious than we currently anticipate, we will know whether we should increase or decrease our insurance premiums over time.

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