Dealing With Uncertainty in Policy Analysis and Policymaking

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"Penetrating so many secrets,
we cease to believe in the unknowable.
But there it sits nevertheless,
calmly licking its chops."
– H.L. Mencken, *Minority Report*, 1956

Policymaking is about the future. If we were able to predict the future accurately, preferred policies could be identified (at least in principle) by simply examining the future that would follow from the implementation of each possible policy and picking the one that produced the most favorable outcomes. However, for most systems of interest today (particularly social and economic systems), such prediction is not possible, due to their increasing complexity, their increasing interrelationships with other systems, and the increasing uncertainty of developments external to the system that have important effects on the system. When even the best model cannot reliably predict the details of a system's behavior, the classical approach of choosing a policy based on the outcomes from a best estimate model is no longer credible. Such policies are 'best' for a future that most certainly will not occur, and have implications for the future that actually occurs that are typically not examined in the course of policy design and analysis. Current approaches to policy analysis have serious difficulties in dealing with problems characterized by complexity or disequilibrium behavior, systems undergoing significant organizational and structural change, and systems that can only be influenced rather than controlled. Yet, these characteristics have increasingly become staple characteristics of the world in which we live. Such systems are fundamentally unpredictable. Yet, rapid economic, political, and social changes are a reality, and public policies must be devised in spite of profound uncertainties about the future.

Even though the future cannot be predicted, it is possible to prepare for it. If, in the face of massive uncertainties, public policies are to be useful and credible, new approaches will be needed for dealing with uncertainty. This special issue of *Integrated Assessment* is a first step in filling this need. The papers in this issue are drawn from a session entitled "Dealing With Uncertainty in Policy Analysis and Policymaking" that was part of the 5th International Conference on Technology, Policy and Innovation, which was held in The Hague in June 2001.

There are five papers in this collection. They can be divided into two categories:

1. How can uncertainty in policy analysis and policymaking be characterized (what is it? how can it be placed in a historical context? how can we classify different types of uncertainties?)?
2. How can policy analysts and policymakers deal with uncertainties (i.e., how can policies be developed that have a good chance of succeeding in spite of enormous uncertainties about the future?)?

1. CHARACTERIZING UNCERTAINTY

That uncertainties exist in practically all policymaking situations is generally understood by policymakers and policy analysts. But there is little appreciation for the fact that there are many different types of uncertainty, and there is a lack of understanding about their relative magnitudes and the different tools that are appropriate to use for dealing with the different types. Even within the community of policy analysts who deal with uncertainty in their work, there is no commonly shared terminology, and no agreement on a typology of uncertainties. The first paper (by Walker, Harremöes, Rotmans, van der Sluijs, van Asselt, Janssen, and von Krauss) aims to provide a conceptual basis for the systematic classification of uncertainty in model-based decision support activities, such as policy analysis, integrated assessment, and risk assessment. As van Asselt [1] notes, any typology of uncertainties is context dependent. In fact, according to her, uncertainty type by definition "refers to the way in which uncertainty manifests itself in a particular context." The context for the typology of uncertainty presented in this paper is model-based decision support. The authors first define uncertainty in model-based

decision support as *any deviation from the unachievable ideal of completely deterministic knowledge of the relevant system.* They then distinguish the following three dimensions of uncertainty:

 (i) the *location* of uncertainty – where the uncertainty manifests itself within the model complex;
(ii) the *level* of uncertainty – where the uncertainty manifests itself along the spectrum between deterministic knowledge and total ignorance;
(iii) the *nature* of uncertainty – whether the uncertainty is due to the imperfection of our knowledge or is due to the inherent variability of the phenomena being described.

They end up proposing a matrix that can be used to characterize uncertainty in any model-based decision support situation. The information in the filled-in matrix can then be used to provide a conceptual framework for better communication among analysts as well as between them and policymakers and stakeholders. It can also be used to help in identifying, articulating, and prioritising critical uncertainties, which is a crucial step to more adequate acknowledgement and treatment of uncertainty in decision support endeavours and more focused research on complex, inherently uncertain, policy issues.

In the second paper, Harremöes suggests that the presence of uncertainty in policymaking situations with respect to technological development should be explicitly acknowledged, that this acknowledgment may lead to a paradigm shift in the approach to choosing policies, and that, as a result, there may be fewer negative 'surprises' from the policies that are implemented. The traditional Western scientific approach is based on causality – i.e., a more or less deterministic interpretation of the laws of nature. This approach, which makes simplifying assumptions about complex situations and disregards uncertainties about causality, has led to many mistakes with respect to human health and to the environment. A century ago, basic physics developed beyond Newtonian physics into quantum mechanics, in which the stochastic elements overshadow deterministic predictability. The increasing complexity of integrated social systems, together with theoretical developments such as chaos theory, theories of self-organization, and catastrophe theories, is now giving rise to fundamental concerns regarding deterministic approaches for estimating the effects of technology changes. Harremöes cites many 'surprises' resulting from environmental policies and suggests that application of the precautionary principle might have helped in many of these situations – situations in which ignorance and indeterminacy dominate the cause-effect relationships. For this approach to work, however, will require fundamental changes in the attitudes of scientists and politicians. Politicians will have to accept that fuzzy answers may be the best expression of expertise; scientists will have to learn that the identification of the fuzzy borderline

between knowledge and ignorance may be the sign of real competence.

2. DEALING WITH UNCERTAINTY

Most uncertainties cannot be eliminated; they must be accepted, understood, and managed. Traditionally, policy analysts and policymakers have dealt with uncertainty about the future in one of two ways. The first (and most common) is to ignore it – to overlook it or act as if it is not there. An implicit assumption is made that the future world will be structurally more or less the same as the current world – perhaps more populated, richer, dirtier – but, essentially the same or an extrapolation of the past. Of course, this does not solve the uncertainty problem. It merely sweeps it under the rug, and can have serious consequences.

The second approach to dealing with uncertainty about the future is more enlightened. It corresponds to the current policymaking paradigm and forms the basis for traditional 'what-if' policy analysis. It worked fairly well in the past when change was more gradual and predictable, there was less global competition, and the consequences of being wrong were smaller. The central assumption of this paradigm is that the future can be predicted sufficiently well enough to identify policies that will produce favorable outcomes in one or more specific plausible future worlds. The future worlds are called scenarios. Policy analysts use best-estimate models (based on the most up-to-date scientific knowledge) to examine the consequences that would follow from the implementation of each of several possible policies in each scenario. The 'best' policy is the one that produces the most favorable outcomes across the scenarios. (Such a policy is called a robust policy.) The problem with this approach is that the resulting policy is best for specific scenarios that are fairly certain not to occur, since any given scenario has a probability zero of actually occurring. More important, the resulting policy has implications for the future that actually occurs that were probably not examined in the course of the analysis and that are generally not revisited as the future unfolds.

This approach has had its successes in the past and can work quite well – in fact, its popularity can be traced to its success in helping the Shell Oil Company handle the oil crisis in the early 1970s. However, if a policy is based on a variety of assumptions about the future and some of those assumptions turn out to be wrong, the negative consequences can be as bad as if the uncertainty about the future had been totally ignored. Consider the recent case of planning for the future of the main airport in The Netherlands: Schiphol Airport. In 1995, after a two-year multi-phased deliberative process known as "physical planning key decision Schiphol" (PKB Schiphol), some major decisions were made by the Dutch Parliament that were intended to guide the growth of civil aviation in the Netherlands to the year 2015.

One of the outcomes of the PKB-Schiphol process was the decision to constrain the number of passengers at Schiphol to no more than 44 million passengers per year. This constraint was supposed to be more than enough to accommodate the most optimistic estimates of passenger growth until at least the year 2015. These limits will certainly be reached well before then. And the noise limits, also expected to be reached no sooner than 2015, were reached in 1999.

How did such a long, costly, and deliberate planning process do such a poor job in forecasting the growth in air traffic at Schiphol? The passenger and noise projections were based on passenger forecasts that were produced by a model developed by the Netherlands Central Planning Bureau (CPB). This model assumes that the number of passengers passing through Schiphol is directly related to the value of the Netherlands' Gross Domestic Product (GDP). This assumption was based upon the fact that, up until the time the model was built, there had been a very close relationship between the GDP and the number of passengers passing through Schiphol.

Of course, no one knows with certainty what the GDP will be in 2015. So, the CPB developed three scenarios, each with a different value of GDP, which were then used to produce three forecasts of the number of passengers at Schiphol in 2015. The 44 million figure corresponds to the forecast based on the highest GDP growth rate of the three scenarios. The actual growth of GDP through 1999 was closest to the assumptions in the low-growth scenario. Nonetheless (as shown in Fig. 1) the growth in the number of passengers during this period was significantly more than what was forecast using the assumptions from the high-growth scenario – called Balanced Growth.

What happened was that a number of trend breaks – unanticipated changes in the world of civil aviation – had occurred after the forecasts had been made. The forecasts had assumed that the future would be a continuation of the past. But, in fact, three factors that have little to do with GNP growth rates were responsible for the rapid growth of air traffic at Schiphol:

1. The growth of hub-and-spoke networks, with Schiphol becoming a hub airport for KLM, where it cross-connects transfer passengers whose destination is not Amsterdam but is some other KLM city. Most of the growth in passenger traffic through Schiphol has come from an increase in the number of transfer passengers carried by KLM. (The transfer traffic at Schiphol grew from 27% in 1990 to 43% in 1998.)
2. A code-sharing alliance between KLM and Northwest Airlines, which feeds Northwest's European traffic through KLM, and therefore through Schiphol.
3. The European Union's decision to liberalize the air transport industry – to reduce national monopolies and increase competition among airlines. As a result of this decision, European airlines faced competitive pressures that they did not have to face in the past, fares fell, and the demand for air travel increased.

So, great care must be taken in developing and using scenarios to deal with uncertainty about the future. Recently, a new set of approaches has emerged to deal with uncertainty about the future [2]. They are based upon the following line of reasoning:

(1) In this unpredictable rapidly changing world, it is almost impossible to identify robust policies – fixed static policies that will perform well against all plausible futures.
(2) Over time, we gain information that resolves current uncertainties about the future.
(3) Thus, the best policies will be adaptive (take those actions now that cannot be deferred; prepare to take actions that may later become necessary; monitor changes in the world and take actions when they are needed).
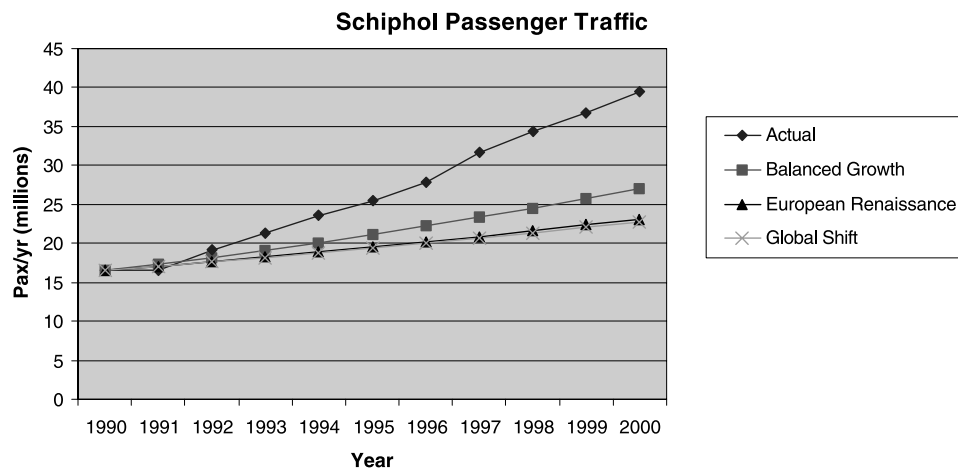

Fig. 1. Actual and Projected Growth of Passenger Traffic at Schiphol Airport (1990–2000).

These 'adaptive' approaches explicitly focus on monitoring the validity of the assumptions underlying policies as time proceeds, knowledge increases, and events unfold – specifying actions that should be taken to adjust to the new circumstances. In this special issue these approaches have been applied to three major policy fields: technology policy, climate change, and transport.

In the first of these adaptive approaches (the third paper in this issue), de Neufville presents the 'real options' approach for dealing with uncertainty in planning and design of technological systems. The real options methodology was developed in response to the inadequacies of traditional methods, such as net present value (NPV), for the evaluation of capital budgeting decisions under uncertainty. NPV produces all-or-nothing ''go/no go'' decisions, which do not properly recognize the value of learning more before a full commitment is made. Real options is based on options analysis, which is widely used for executing contracts on a variety of widely-traded financial instruments, commodities, and services. Traditionally, a good system design minimizes risk. It focuses on increasing reliability. Thinking in terms of options, however, recognizes that uncertainty adds value to options. Systems design from this perspective includes ongoing processes of information gathering to ensure that options can be exploited at the correct time and leads designers to build more flexibility into a system than is common in current practice, since it enables managers and designers to estimate the value of system flexibility. For instance, one can build a bridge for cars with the access and strength to eventually carry trains, even though trains are not currently needed. As a result, a real option is built into the system. If needed, a rail line can be added at relatively low cost in the future. Real options can also identify the price level of a certain input that should trigger a decision to abandon production, or when to keep the option of investing in a project open, instead of exercising the option immediately.

In the fourth paper of this issue, Marchau and Walker focus on policymaking regarding Advanced Driver Assistance Systems (ADAS) – electronic systems that support the driver in controlling his vehicle in a better way. Policy development regarding ADAS is hindered by large uncertainties about the outcomes of large-scale ADAS implementation and the valuation of the outcomes by the stakeholders involved in or affected by implementation decisions. In order to deal with these uncertainties, a flexible or adaptive policy is proposed that takes some actions right away and creates a framework for future actions that allow for adaptations over time as knowledge about ADAS accumulates and critical events for ADAS implementation take place. The adaptive approach is illustrated in two contexts: (1) ADAS for road traffic safety, and (2) ADAS for road traffic efficiency. This illustration showed that, compared to traditional policymaking, the adaptive approach is highly promising in terms of handling the range of uncertainties related to ADAS implementation for traffic safety and efficiency.

The final paper by Morgan integrates the two categories of papers in the issue. It begins by reviewing some basic ideas about uncertainty in model-based policy analysis that are found in the literature. It then uses integrated assessment of climate change as a vehicle to explore limitations to conventional policy analysis and the treatment of uncertainty. Because the climate problem is global in scope, and because it involves large changes that unfold on a time-scale of several centuries, standard analytic methods for policy analysis cannot be appropriately applied. Morgan suggests that, rather than trying to search for a long-term optimal policy, models be used to search for robust policies that do well in the face of uncertainties about both coefficient values and model structures, and that adapt to changes in the world as information is gathered about the future situation.

Summarizing, in this issue, the difficulties of defining and handling uncertainty in policy analysis and policymaking are laid out. Of course, there are different approaches for handling the different types. However, the main challenge involves the development of overall approaches, which can handle the different types of uncertainty and their inter-relationships within a common framework. Uncertainty is inherent in the very nature of making policies for the future and in the dynamic behavior of the systems being affected. The acceptance of this fact opens up possibilities for the successful development and use of multi-disciplinary, multi-method approaches, based on the integration of quantitative and qualitative research, which recognize and handle the full spectrum of uncertainties. We hope that this issue will contribute to the further development of such approaches.

REFERENCES

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