AGU100 ADVANCING EARTH AND SPACE SCIENCE

Earth's Future

COMMENT
10.1002/2017EF000750

This article is a comment on by Glynn et al. (2018) https://doi.org/10.1002/2016EF000487.

**Key Points:**
- Glynn et al. assume that predictive optimization models can identify a "best policy," not acknowledging the role of uncertainty policymaking
- They have an adaptive framework for knowledge generation and decision evaluation, but not for changing the decision as the world changes
- We show how their paper's narrow view can be widened to include aspects of risk and uncertainty

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**Citation:**
Walker, W., Marchau, V., Bloemen, P., Lawrence, J., Lempert, R., & Kwakkel, J. (2018). Comment on "From data to decisions: Processing information, biases, and beliefs for improved management of natural resources and environments" by Glynn et al. *Earth's Future*, *6*, 757–761. https://doi.org/10.1002/2017EF000750

Received 8 NOV 2017
Accepted 23 MAR 2018
Accepted article online 6 APR 2018
Published online 6 MAY 2018



# Comment on "From Data to Decisions: Processing Information, Biases, and Beliefs for Improved Management of Natural Resources and Environments" by Glynn et al.

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**Abstract** Glynn et al. (2017, https://doi.org/10.1002/2016EF000487) note the importance of engaging stakeholders in the process of public policymaking and analysis. In particular, they highlight the central role biases, beliefs, heuristics, and values play in such engagement. However, the framework they propose neglects uncertainty, which significantly restricts any ability to engage effectively with BBHV. We show how their paper's narrow view can be widened to include aspects of risk and uncertainty.

## 1. Introduction

Glynn et al. (2017) note the importance of engaging stakeholders in the process of public policymaking and analysis. In particular, they highlight the central role biases, beliefs, heuristics, and values (BBVH) play in such engagement. However, the framework proposed by Glynn et al. neglects uncertainty, which significantly restricts any ability to engage effectively with BBHV.

Appropriate consideration of uncertainty goes far beyond replacing point forecasts with best-estimate joint probability distributions over future states of the world. Rather, uncertainty is fundamental to how both producers and users of scientific information understand and use that information. In his The Idea of Justice, Sen (2009) argues that fundamental attributes of our world include a diversity of beliefs and values as well as irreducible uncertainty about the consequences of our actions. These two attributes intertwine in any attempt to provide salient, credible, and legitimate decision support for complex problems such as climate change and sustainability. In evaluating the credibility of forecasts, stakeholders seek congruence between the perceived nature of the uncertainty and its representation (Du et al., 2011; Wallsten & Budescu, 1995). Stakeholders are likely to view with suspicion overly precise forecasts for complex future Earth systems. The concept of "social construction of risk" emphasizes the extent to which judgments about uncertainty are intertwined with BBVH (Mary Douglas). "Cultural cognition" highlights the extent to which scientific information is shifted through values-based filters and trusted social networks (Dan Kahan). The concept of "wicked problems' emphasizes the challenges that arise when uncertainty intersects with differing, values-driven problem framings. The literatures on scenarios, iterative risk management, and risk governance (see for instance, Box 1-3 in the 2012 IPCC Special Report on Extreme Events (IPCC, 2012)) all aim to provide frameworks for engaging stakeholders under such conditions. Neglecting the central role of uncertainty will hobble any attempt to improve the quality of decisionmaking when "facing new, complex issues of situations especially if they need to be managed for the benefit of a wider community, for the longer-term and the larger-scale." (Glynn et al., p. 1; quote from abstract).

This response to Glynn et al. suggests how that paper's proposed framework could begin to address the fundamental concept of uncertainty. This response begins by defining a generic framework for dealing with uncertainty. This framework is next used to specify shortcomings in Glynn et al.'s treatment of uncertainty and how it can be dealt with in making policy decisions. The paper ends with some notions from the field of uncertainty research that we hope will inspire researchers in the field of BBHV.

**Table 1**
*The Progressive Transition of Levels of Uncertainty From Complete Certainty to Total Ignorance*

| Level of uncertainty | Future situation | Response |
|---|---|---|
| 1 | …is knowable (*little uncertainty*) | "predict and act" policies and/or actions |
| 2 | …will behave in much the same way as the past (*statistical uncertainty*) | "trend-based" policies and/or actions |
| 3 | …is well described by a few overarching scenarios (*scenario uncertainty*) | "static robust" policies and/or actions |
| 4 | …is unknown or disagreed upon by experts and/or stakeholders, with no consensus on what the future might bring (*deep uncertainty*) | adaptive policies and/or actions |

*Note*. Source: Based on Walker et al. (2013), pp. 227–229.

## 2. A Framework For Dealing With Uncertainty

Making plans for the future depends on anticipating changes, especially when making long-term plans or planning for rare events. Consider, for example, decisions or concerns affected by the consequences of climate change; the future demand for mobility; the planning of megaprojects, which energy sources to rely on in the future; the role of information and communications technology in healthcare; or how cities will develop. Or think of rare events like a natural disaster, a financial crisis, or a terrorist attack. These situations are all characterized by a high degree of uncertainty. Ignoring uncertainty could lead to large adverse consequences, and policymakers have an interest in limiting the possibility of such adverse consequences happening.

In a broad sense, uncertainty may be defined simply as missing knowledge, that is, the absence of information. With respect to decisionmaking, uncertainty refers to the gap between available knowledge and the knowledge decisionmakers would need in order to choose a policy that meets the objectives across a range of plausible futures. This uncertainty clearly involves subjectivity, since it relates to satisfaction with existing knowledge, which is colored by the underlying values and perspectives of those involved in the decisionmaking process. But this in itself becomes a trap when implicit assumptions are left unexamined or unquestioned. Uncertainty can be associated with all aspects of a problem of interest (e.g., the system comprising the decision domain, the world outside the system, the outcomes from the system, and the importance stakeholders place on the various outcomes from the system).

In recent years, a great deal of attention in the public policymaking literature has been devoted to making decisions in the face of uncertainty. Many tools and approaches have been developed to support decisionmaking under uncertainty, which can be structured by considering the many dimensions of uncertainty.

Walker et al. (2003), as modified by Kwakkel et al. (2010), identified three dimensions of uncertainty. The first dimension is the location of uncertainty—where the uncertainty is located in the policy analysis framework (in the external context, the system model, the system outcomes, or the weights on the outcomes). (For a description of the policy analysis framework, see Walker, 2000.) The second dimension is the level of uncertainty (they specified four levels, ranging from little to deep uncertainty). This is an expression of the degree or severity of the uncertainty. The third dimension is the nature of the uncertainty. The phenomena about which we are uncertain can either be due to our lack of knowledge about the phenomena (i.e., epistemic uncertainty), the inherent variability in the phenomena (i.e., uncertainty inherent in their nature), or differences in framing by the participants in the decisionmaking process (which Brugnach et al., 2008, call ambiguity in their application of the uncertainty framework).

## 3. Criticism 1: Too Narrow Dealing With Uncertainty

Considering the "level" dimension of uncertainty, Walker et al. (2003) defined four levels, based on the amount of knowledge, there is about the future situation. Policy analysts have different approaches to design policies for the different levels (see Table 1). The different levels of uncertainty can lead to very different types of decisions/policies. The same policy problem can include elements of each level of uncertainty. It is therefore important to be transparent about the relationship between the level of uncertainty and the response taken (i.e., the appropriate type of policy). By implicitly assuming that the future is knowable, Glynn et al. are assuming that they have only to deal with Level 1 uncertainties.

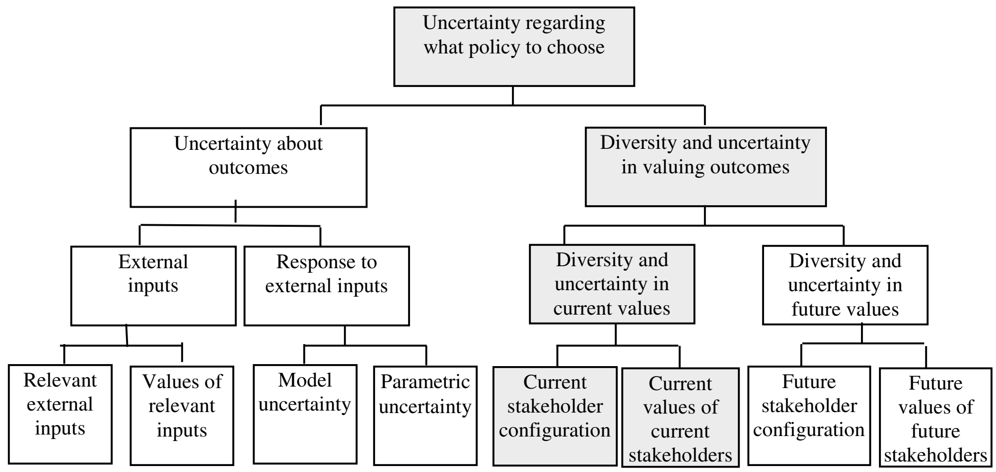


**Figure 1.** A typology of uncertainty (based on Walker et al., 2013, p.225).

Figure 1 can be used to show how the Glynn et al. paper's narrow framing (the shaded part in the figure) can be widened to include dealing with all locations of uncertainty by distinguishing between uncertainty about the *outcomes* of policy decisions and uncertainty about the *valuation of the outcomes* of policy decisions. The paper's approach to answering the question of what policy to choose is to focus on uncertainty about the valuation of outcomes (the branch on the right side of the figure), and then to follow only the path involving *current* values. The remainder of the "uncertainty tree" shown in the figure about the uncertainty of outcomes and future values, although relevant for making decisions affecting the future world in the face of uncertainty, is ignored.

*Outcomes* of policy decisions are those characteristics of the system that are considered relevant for the evaluation of policy measures. Uncertainty about outcomes can result from uncertainty about *external inputs* and/or uncertainty about *system responses* to these external inputs. The paper assumes that the input and system responses are known and that there is a system model that can be used as a predictive model. For example, the authors claim that "predictions are essential," and that these predictions need to be "traceable." Uncertainty about external inputs refers to inputs that are not controllable by the decisionmaker but may influence the system significantly, that is, exogenous influences. Even if there were certainty about the external inputs to the system (that is, we knew how the external world would develop), there might still be uncertainty about how the system would respond to those external inputs. The system response might be uncertain because of *model uncertainty* and/or *parametric uncertainty*. Model uncertainty refers to the missing knowledge about the system components, the relationships among them, and the values of the parameters describing the relationships.

The second category of uncertainty refers to the *valuation of outcomes*—that is, the (relative) importance given to the outcomes by crucial stakeholders. It involves uncertainty about how stakeholders value the results of the changes in the system. One can distinguish uncertainty about *current values* related to different perceptions, preferences, and choices the system's stakeholders currently have regarding outcomes. This is the focus of the paper's "adaptive framework." This raises two problems. First, it is difficult to engage in an adaptive learning process related to values without recognizing the strong connection between values and perceptions of risk and uncertainty. Second, values may change over time in unpredictable ways, leading to different valuations of future outcomes than those made by the current stakeholders. New stakeholders might emerge and/or current stakeholders might leave the decision arena. These changes in stakeholders and values can affect policy decisions today in substantial ways. This branch of *future values* in the "uncertainty tree" is ignored by the paper.

## 4. Criticism 2: Too Little Treatment of Ambiguity

There are multiple stakeholders involved in almost all model-based decision support activities. These different stakeholders have a heterogeneous background. This implies that different opinions, experiences, expectations, values, and forms of knowledge are present, which contributes to uncertainty in the weights (in the location dimension) and uncertainty in the frames (in the *nature* dimension). Glynn et al., by focusing on BBHV, restrict their attention to these two dimensions of uncertainty, completely ignoring the *level* dimension. By doing so, they implicitly assume that the future is knowable and that "optimal" solutions can be identified for policy problems (assuming that agreement can be reached among the stakeholders). In fact, in several places in their paper, Glynn et al. explicitly refer to optimal solutions. However, one important insight gained from uncertainty research is that choosing an "optimum" solution for a single most probable end situation, or a limited set of plausible futures, is risky.

The third dimension of the Walker et al. typology of uncertainty is the "nature" dimension. In their original paper specifying the typology (Walker et al., 2003), the authors identified two aspects of the nature dimension: epistemic uncertainty (uncertainty due to lack of knowledge about the phenomena) and ontological or aleatory uncertainty (uncertainty due to variability). However, a companion paper (Kwakkel et al., 2010) added ambiguity to the nature dimension. Ambiguity is defined as uncertainty arising from the simultaneous presence of multiple frames of reference about a certain phenomenon (Brugnach et al., 2008; Dewulf et al., 2005). It relates to the fact that in complex decisionmaking problems there are generally multiple possible and legitimate ways of interpreting the available information. There are multiple stakeholders involved in almost all model-based decision support activities. These different stakeholders have a heterogeneous background. This implies that different opinions, experiences, expectations, values, and forms of knowledge are present. In such situations, there is no obvious correct way of framing the decision problem at hand. This plurality can give rise to a lack of clarity, misunderstandings, and value conflicts. Therefore, Kwakkel et al. (2010) explicitly include ambiguity as an additional category of the nature dimension, in order to highlight the importance of how the same data can be interpreted differently by different actors depending on differences in frames and values. This is the heart of Glynn et al.'s discussion of BBHV. So with respect to the uncertainty typology, their paper is focused on the "nature" dimension.

However, although focused on BBHV, their paper largely ignores the vast literature on this topic, including the literature on "risk governance" (Renn, 2008) and the "social construction of risk" (Dake, 1992). Sociologists, anthropologists, and other social scientists have addressed risk as a social or cultural concept (Douglas & Wildavsky, 1982; Nelkin, 1989). This research suggests that concerns about risk may depend less on the nature of the actual danger than on political, economic, or cultural biases. According to Renn (2008), risk governance goes beyond traditional risk analysis to include the involvement and participation of various stakeholders, as well as consideration of the broader legal, political, economic, and social contexts in which a risk is evaluated and managed.

## 5. Conclusions

1. Glynn et al. observe "collectively, we humans do not have a natural, visceral, ability to consider, far into the future, potential new states of the world and the needs of future generations and a global community. This severely limits the abilities of communities to plan ahead and invest wisely, especially when potential long term, large-scale, diffusely perceived benefits, at the expense of acutely perceived, short-term, local, or individual costs" (p. 2). For exactly this reason, several approaches for dealing with deep uncertainty about future conditions have been developed.
2. Looking at the broad spectrum of uncertainties regarding the choice of a policy, the Glynn et al. paper focuses only on the branch of the uncertainty typology of Figure 1 related to "current values" and assumes that all other uncertainties belong to Levels 1 and 2 shown in Table 1. There is a large literature dealing with the remaining elements of the uncertainty typology and the remaining levels of uncertainty. It is critically important for these elements to be taken into account in making policy decisions using the appropriate approach.
3. In several places in their paper, Glynn et al. refer to optimal solutions. One important insight gained from uncertainty research is that optimizing solutions to a single most probable end situation, or to a limited set of plausible futures, is a risky road. When dealing with deep uncertainty, "satisficing" (doing reasonably well across a broad range of possible futures, or "minimizing maximum regret") is considered a better approach than optimizing.
4. The other issue with optimality is that it inevitably requires prediction or assigning probabilities to aspects of the future state of the world in circumstances that render these evaluations highly dubious. Beyond the

substantive challenges to doing so reliably, this diverts attention from what is the true concern—determining what short-term actions might prove conducive to achieving long-term goals across a wide set of plausible futures.

5. The concept of BBHV may be useful in coming to grips with the challenge of dealing with deep uncertainty in the valuation of outcomes in designing adaptive public policies, so long as the uncertainties about the future are built into the analysis.

**Acknowledgments**
Funding for the authors was provided by their respective affiliated institutions. We are not aware of any conflicts of interest.

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