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Published Version Information

Citation: Peterson, J. M., & Schoengold, K. (2008). Using numerical methods to address water supply and reliability issues: Discussion. American Journal of Agricultural Economics, 90(5), 1350-1351.

Digital Object Identifier (DOI): doi:10.1111/j.1467-8276.2008.01229.x

Publisher's Link: http://ajae.oxfordjournals.org/content/90/5/1350.full.pdf+html

Using Numerical Methods to Address Water Supply and Reliability Issues: Discussion

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Economists and other social scientists are increasingly applying numerical methods to understand human behavior. This interest follows on a longer history of numerical approaches among natural scientists, who for some time have relied on them as tools for basic as well as applied research. As the authors in this session have pointed out, the power of numerical methods is that they do not confine the researcher to model environments with closed-form analytical solutions.

Numerical methods have been a common avenue for resource economists to work with other disciplines. Numerical models of microeconomic decisions with environmental impacts – such as withdrawing groundwater for irrigation – have been coupled with biophysical process models predicting the effects of those decisions on the resource under study. This coupling is often complicated by the incompatibility of model outputs and inputs. For example economic models typically require information on biophysical relationships as differentiable functions. However, a typical biophysical

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model does not produce a function as output but rather a single point that lies on the function. This disconnect can be resolved with functional interpolation techniques which construct a smooth function from a small number of values that are known to lie on its surface. Interpolation is one of several categories subsumed under “numerical methods.”

In the first paper Stratton, Simon, and Marchiori applied functional interpolation in a novel way. While they evidently did interpolate a function from the results of a groundwater model, their main focus was to interpolate a reduced form relationship between groundwater levels and political economy parameters. Given the rules of bargaining set by the central government, their bargaining model simulates the water policies to which local stakeholders will agree. Nested within the bargaining model is an individual decision model which predicts how irrigators will respond to a given policy. From the predicted irrigation decisions the interpolated groundwater equation then predicts the impact on the aquifer. Thus, each run of the model predicts the ultimate hydrologic impact stemming from a particular set of bargaining rules. The authors solved this computationally intensive model at 18 specific points, from which they interpolated a surface.

The authors faced a considerable challenge in describing an analysis of such complexity in the available space. They understandably chose to focus on their interpolated surface and the associated policy implications. Without any explanation of the bargaining model that generated the data for the interpolation, however, their results were difficult to interpret. A working paper by the same authors explains their model in more detail. But even after reading this paper, a number of issues are still unclear, such as the values of many key parameters and how the 18 interpolation points were chosen. The latter issue is not trivial because interpolation errors are likely to magnify in parts of the surface that are far away from any of the interpolation points.

Overall, while additional details would have been helpful, Stratton, Simon, and Marchiori nicely illustrate how numerical methods can provide insight on a resource policy question. Relying on analytical methods alone in their situation would have required much of the rich and relevant detail to be assumed away. Similarly, econometric tools are of limited value in such prospective policy situations, where data on the effects of the instruments being considered are lacking.

In the second paper Hanson, Howitt, and Williams use the output of a hydroeconomic water optimization to predict water prices in an options market. The use of options contracts for water management is likely to become increasingly important due to water scarcity and the stochastic nature of water supply. Certain regions lend themselves well to the use of options contracts. In particular those areas which generally have a sufficient water supply for all uses but occasionally suffer from drought may benefit from the development of options markets. Previous research on options markets has been limited, despite the promising features of these markets.

Hanson, Howitt, and Williams describe the development of the LFN (limited foresight netflow) model, a modification to the CALVIN optimization model. The LFN model is used to predict the value of options contracts for water, and those predicted values are compared to existing contracts. A benefit of using the LFN model to predict options values is that the hydrological information that is used as an input into CALVIN covers 72 years, while the history of options contracts in California is limited to recent history. Some of the challenges involved in developing the model are discussed in the paper.

While certain limitations of using an optimization model are described, the authors neglect to discuss what could be viewed as the most important limitation. The most important problem with optimization models is that they predict optimal behavior instead of actual behavior. In reality studies frequently show that individuals do not respond to changing conditions in the economically optimal way. This limitation of the model should be discussed in more detail as well as the implications of this reality for the results. This seems particularly relevant given the fact that there is a significant difference between the prices predicted by the model and the actual transactions that have been observed. There are only a couple of historical transactions, so these transactions should not be considered a competitive market outcome. However, additional discussion on the reason for the discrepancy would be beneficial.

An area of research that could be a useful extension of this model is to explore the multi-year aspects of risk. Each year is independent in the modeling and simulation. In reality droughts often span multiple years, while wet periods also span multiple years. This multi-year issue could impact the value of an option, as the risk associated with dry periods is increased with repeated dry years. Municipalities are better able to manage one dry year than multiple years in a row.

As with the paper by Stratton, Simon, and Marchiori, additional details would be helpful to fully evaluate the results. However, the paper provides a useful background on the use of hydroeconomic models in the evaluation of water policy choices as well as the potential benefits of options markets for water.

Together, these two papers provide interesting applications of the use of numerical methods in evaluating water policy. Such methods have not been used frequently in the past but show considerable promise and usefulness to both researchers and policymakers.