Economic Valuation and Application of Services

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Abstract

The application of economic valuation to hydrometeorological services has gained prominence as national meteorological and hydrological services (NMHS) focus more on providing gains to society. In addition, NMHS programs are increasingly called on to justify their budgets. In this paper we briefly discuss several issues related to the economic valuation and application of hydrometeorological services. We first make a distinction between "the economy" and "economics" to encourage a clear understanding of what valid and reliable economic research and application can do to support NMHS efforts. Next, we cover some issues related to data validity, which leads into a discussion of appropriate methods for economic assessment, particularly benefit-cost analysis. Then we describe a soon-to-be-released resource—a primer on economics for NMHS—and summarize the paper's conclusions. A brief discussion of available resources rounds out the paper.

Introduction

As discussed in *Elements for Life* (2007), published in conjunction with the UN International Conference on Socio-Economic Benefits of NMHS Services (Madrid, Spain, 19–23 March 2007), there are several reasons for assessing the economic value of hydrometeorological services (Lazo 2007). These include

- Justifying programs to decision makers (e.g., funding agencies)
- Evaluating programs for their economic viability
- Guiding research investment to maximize benefits to society
- Informing users about benefits to encourage their involvement in or use of hydrometeorological programs
- Developing end-to-end-to-end systems where user needs are incorporated into the research, design, and implementation of hydrometeorological programs.

Here we discuss several issues related to the economic valuation and application of hydrometeorological services. We first make a distinction between "the economy" as the term is often used in common parlance and "economics" as a social science. Next, motivated by recent work on impact damage estimation, we explore some issues related to the validity and reliability of data on damages from hydrometeorological events—an effort that should undertake valid economic assessment just as the valuation of benefits from hydrometeorological services does. This leads into a discussion of appropriate methods for economic assessment. As part of an effort to build a foundation for the use of economic research and applications, we describe a resource we are developing, the *Primer on Economics for National Meteorological and Hydrological Services*.[1] We will be releasing this primer as an introductory overview of benefit-cost analysis (BCA) to encourage the use of appropriate economic methods for assessing hydrometeorological programs.

The Economy and Economics

Measuring the economic impact of hydrometeorological services and information typically involves assessing the impact of hydrometeorological events or forecasts of events on specific economic sectors such as transportation, energy, or agriculture. Changes in measures of output, employment, revenues, or taxes are presented as the economic impacts of these events or forecasts.

Although these measures do result in useful information, we would like to make a distinction between "the economy" and "economics." Merriam-Webster (http://www.m-w.com) defines *economy* as "the structure or conditions of economic life in a country, area, or period; also: an economic system." The term economy, then, is usually construed as the productive system of a country or region, and economic impacts are interpreted as disturbances to productive activity. Output, employment, revenues, or taxes are all related to productive activity – but they do not necessarily indicate changes in societal well being.

In what seems to follow the same conceptual meaning focusing on production, *economics* is defined as "a social science concerned chiefly with description and analysis of the production, distribution, and consumption of goods and services" (http://www.m-w.com). But digging deeper we find that ***social sciences*** are concerned with understanding "the institutions and functioning of human society and with the interpersonal relationships of individuals as members of society (http://www.m-w.com)." As a field of study of human behavior, economics extends well beyond the productive activities of an economy; economics as a social science considers the full range of impacts on individuals, firms, and society. This includes changes in public goods, environmental effects, health impacts, population distributions, vulnerable populations, and all other aspects of individual and societal welfare. Welfare economics is the area of economics specifically

[1] In this paper, we use the term "national meteorological and hydrological services" or simply "NMHS" to refer generically to the body of weather-water-climate–related services and informational products provided by the agencies or entities responsible for such services. Many countries have both public sector and private sector entities that provide hydrometeorological services, and different countries offer different sets of services under different program names, but all countries deliver hydrometeorological services in some form. Here and in the primer, we focus primarily on public provision of weather-water-climate–related services and informational products. As indicated by the World Meteorological Organization, "NMHSs constitute the single authoritative voice on weather warnings in their respective countries, and in many they are also responsible for climate, air quality, seismic and tsunami warnings" (see http://www.wmo.int/pages/governance/policy/ec_statement_nmhs.html).

concerned with the overall welfare of society, including economic efficiency and income distribution.

Focusing only on the economy as a system of production can bias decisions toward purely monetary/economic outcomes and neglect adequate consideration of overall societal welfare. According to Lazo et al 2007a,

> The distinction between measures of economic activity and measures of economic welfare is important. Measures of activity, even if expressed in monetary units (e.g., output), do not tell us the *value* of the activity. In other words, these measures do not tell us what people would be willing to pay for that activity. Welfare measures, on the other hand, are specifically designed to quantify what people are willing to pay for something. As a result, welfare measures of benefits are appropriately compared to the costs that people pay for those benefits.

We emphasize the distinction between "the economy" and "economics" to clarify that

- Economics as a social science considers societal welfare and not just productive activity.
- Economics has a strong theoretical–methodological framework for assessing and discussing societal welfare that includes a wide range of considerations beyond production activities.

To achieve one of the WMO's stated goals—"a strategic approach to the implementation of the PWSP [Public Weather Services Programme] that would help . . .NMHSs . . . to realise a quantum change in the delivery of products and services[2]"—we encourage continuing to develop a focus on societal welfare rather than the more limited conception of maximizing "economic" measures.

Damage Data

Hydrometeorological services rely on data, and great care, effort, and expense are put into observing, assimilating, manipulating, creating, and disseminating data. In essence, the fundamental function of hydrometeorological services can be characterized as the collection and transformation of data into information; e.g., transforming observations into forecasts. The hydrometeorological community does an incredible job in this complex effort.

But data on damages from hydrometeorological events, although of considerable importance to the hydrometeorological community, receive little attention. We do not address this topic with particular expertise but instead from a position of concern about the quality of damage data we have identified while updating NCAR's *Extreme Weather Sourcebook* (a collection of data on severe weather events in the United States, available at (http://www.sip.ucar.edu/sourcebook/index.jsp). As we worked to update damage data in this resource from 1999 to 2006, we dug deeper into the sources of these data and looked at how damages from hydrometeorological events are assessed in the United States.

As an example, the National Weather Service (NWS) has built "Storm Data,"[3] which is probably the primary source of damage data used in the United States. Under NWS Storm Data guidelines for calculating hail damage to a structure's roof,[4]

[2] See the homepage for the International Symposium on PWS: A Key to Service Delivery: http://www.wmo.ch/pages/prog/amp/pwsp/PWS_Symposium_en.htm.

[3] See http://www.ncdc.noaa.gov/oa/climate/sd/

[4] See the directive defining NWS protocol for collecting and entering data for Storm Data at http://www.nws.noaa.gov/directives/010/pd01016005e.pdf.

only the cost of the new roofing material is considered as damages. The NWS uses this approach, which precludes any consideration of the labor required for repairing damaged structures, to calculate damages from almost all hydrometeorological events in the United States. On the other hand, for hurricane damages, the insurance industry supplies data on insured losses, which are then doubled and reported—by the NWS and others—as the damage from a hurricane. Because insurance data for hurricanes include the costs of labor for replacing damaged property, this information more closely represents the total real cost of repairing or replacing damaged property. Doubling these numbers is an attempt to account for damages to uninsured property and undercounted damages. For a similar incident, then, an approach deriving damage data from insurance industry information would yield a higher damage estimate than the approach used by the NWS.

Neither the NWS approach nor the insurance industry data are likely include, for example, the costs to the members of a household if they must temporarily relocate, their lost wages if they cannot work for some period of time, or the reduction in profits for a company whose employees are absent for some period during recovery from the storm (unless these are specifically covered under some form of loss insurance). We can see, then, that neither approach captures the total societal impact of hydrometeorological events.

Perhaps unaware of the limits of damage data, some researchers have undertaken analysis of available disaster damage data to argue that there have or have not been changes in weather-water-climate–related impacts on society over relatively long periods of time. It is difficult to put much confidence in this type of analysis when the underlying data on damages are of questionable quality. Furthermore, to the extent that decision makers use storm-impact information, there should be concern about their ability to make fully informed decisions. As stated in the supporting material for Bouwer et al. (2007; Table S2): "Because of issues related to data quality, the stochastic nature of extreme event impacts, length of time series, and various societal factors present in the disaster loss record, it is still not possible to determine the portion of the increase in damages that might be attributed to climate change due to GHG [greenhouse gas] emissions." One of the policy recommendations from Bouwer et al. is "We recommend the creation of an open-source disaster database according to agreed-upon standards."

Numerous experts have assessed loss estimation, including

- *The Impacts of Natural Disasters; A Framework for Loss Estimation* (Committee on Assessing the Costs of Natural Disasters; Board on Natural Disasters; Commission on Geosciences, Environment, and Resources; and the National Research Council. Washington, DC: National Academy Press, 1999).
- *The Hidden Costs of Coastal Hazards: Implications for Risk Assessment and Mitigation* (H. John Heinz III Center for Science, Economics and the Environment. Washington, DC: Island Press, 1999)
- *Human Links to Coastal Disasters* (H. John Heinz III Center for Science, Economics and the Environment. Washington, DC: The Heinz Center, 2002)
- *Risk, Vulnerability and Impact Assessment. Report from a Meeting on Improving the Quality, Coverage and Accuracy of Disaster Loss Data* (International Strategy for Disaster

Reduction; formerly Inter-Agency Task Force on Disaster Reduction; Working Group #3. Geneva, May 7, 2004. Available at http://www.unisdr.org/eng/task%20force/tf-working-groups3-eng.htm).

These documents discuss appropriate conceptual and theoretical frameworks for assessing loss from natural disasters and hydrometeorological events, which are largely based on accepted economic theory of social welfare measurement. In addition, assessing societal losses requires valid and reliable economic analysis of costs and benefits of these events, using methods not particularly different from those we discuss in the next section. As a result, we feel that within readily available literature the issues surrounding the need for higher quality damage data are well identified and that a conceptual and theoretical framework for assessing damages already exists. We question, though, whether there is an adequate understanding of the importance of collecting reliable damage data within the hydrometeorological community. We also doubt that it is adequately understood that the currently available damage data are of questionable quality. In the United States at least, the public weather service (NWS) is the agency currently collecting and reporting damage data. We perceive that the agency is investing inadequate resources to ensure that this is undertaken in a reliable and consistent manner.

Economics Primer

To encourage and increase capacity in economic methods, we are completing a document titled *Primer on Economics for National Meteorological and Hydrological Services* (Lazo et al. 2007b).[5]

This primer, which covers economic theory, methods, and applications, is primarily for members of the weather community. It is intended to increase their understanding of economic methods and encourage their application in evaluating both the impacts of NMHS and the associated benefits and costs of those services. To this end, the primer

- Describes the concept and practice of an economic BCA
- Discusses why conducting such economic analyses is important and useful
- Offers guidance on how to conduct BCAs and document and communicate the inputs and outputs of such analyses
- Presents illustrations of economic analysis for NMHS projects in the form of case studies.

Given that weather forecasts are quasi-public goods,[6] the economic value of most weather forecasting services is not directly observed in the market. For this reason, it is difficult to determine the economic value of improvements in weather forecasting. In the primer, we offer guidance on the theories, methods, and applications that can be applied to valuing projects or programs that improve hydrometeorological forecasts.

The primer focuses on a step-by-step approach to BCA. Figure 1 from the primer (reproduced here) outlines these basic steps, which are discussed in more detail at a level accessible to noneconomists in the primer itself. An important part of any valuation effort, as indicated on the right-hand side of Figure 1, is making connections with stakeholders. In the NMHS context, stakeholders

[5] This work was funded in part through the U.S. Voluntary Cooperation Program managed by the NWS International Activities Office.

[6] Weather-water-climate–related services and informational products are referred to as quasi-public goods because of their nonrival and limited-excludability nature.

are typically the users of the information that is to be produced by the program under consideration, but decision makers and different parties within the NMHS itself are stakeholders as well.

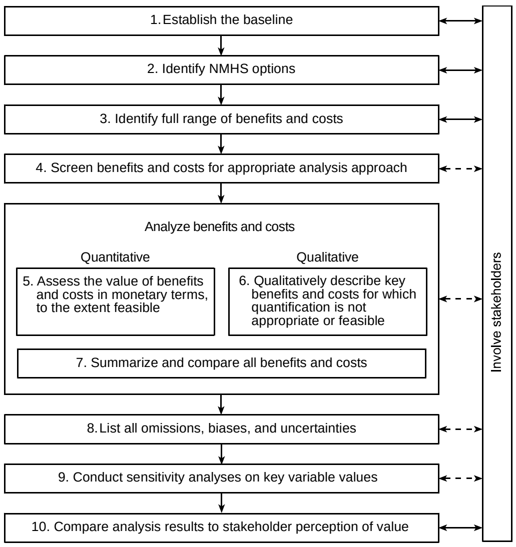

Figure 1. Steps in Conducting an Economic Analysis

Following this core material we discuss specific issues—such as defining a baseline for valuation, choosing which NMHS options to consider, determining benefit and cost categories applicable to NMHS, and screening outcomes—in more detail. We also explain important concepts including methods for determining monetized values, clarifying the difference between market price and nonmarket valuation, discounting and net present value (NPV), setting project decision criteria, and understanding and using sensitivity analysis.

In the final section of the primer, we present five examples of economic analyses that relate to the value of NMHS. These case studies span the entire range of estimation methods—from economic modeling through data analysis to subjective assessment—in addition to a range of objectives. For instance, the objective of Case Study 1 was to estimate the magnitude of impacts from weather variability in the United States, as well as to indicate the sectors of the economy where those impacts are likely to be greatest. The objective of Case Study 3 was to provide a traditional assessment of the costs and benefits of a particular program. Information on each case study includes a summary, methods used, procedures, resources used, data requirements, and economic expertise needed. The five case studies are

1. *Sensitivity of the U.S. Economy to Weather* (Larsen et al. 2007) uses statistical analysis to estimate the degree to which economic output in states, economic sectors, and the overall U.S. economy depends on weather variables. Temperature- and precipitation-related weather variables are considered in the analysis. The authors conclude that total annual U.S. economic output can vary by as much as $260 billion depending on weather conditions.

2. *The Economic Value of Temperature Forecasts in Electricity Generation* (Teisberg et al. 2005) estimates the cost savings from using 24-hour temperature forecasts to plan the next day’s production of electricity in the United States. Such savings are possible because electric power can be generated from a variety of different generating units. This study’s key finding is that the availability of 24-hour temperature forecasts produces annual cost savings in the United States of $166 million, relative to persistence temperature forecasts.

3. *Heat Watch/Warning Systems Save Lives: Estimating Costs and Benefits for Philadelphia 1995–98* (Ebi et al. 2004) examines mortality data for the city of Philadelphia during heat waves that occurred from 1995 through 1998. It finds that mortality was lower when authorities declared a heat wave warning and

took actions to mitigate the effects of extreme heat. The investigators estimate that during this 4-year period, 117 premature deaths from heat were prevented by heat wave warnings and the associated actions. The dollar benefit of these prevented deaths, estimated to be $468 million over 4 years, vastly exceeds the modest cost of the actions taken.

4. *Economic Value of Current and Improved Weather Forecasts in the U.S. Household Sector* (Lazo and Chestnut 2002) employed survey methods in which people were asked questions designed to reveal the values that they place on weather forecasts they use or on possible improvements to those forecasts. The study estimates that the total annual value of current weather forecasts to U.S. households is $109 per household, or $11.4 billion for the United States as a whole. For a package of possible improvements to current weather forecasts, the estimated annual value is $16 per household, or $1.73 billion for the entire nation.

5. *Benefit Analysis for NOAA High Performance Computing System for Research Applications* (Lazo et al. 2003) estimates the benefits to be gained from acquiring new supercomputers to use in research that supports improvements in NWS weather forecasting, as well as a variety of other programs. The investigators reviewed previous work done to estimate the benefits of weather forecasts, especially the benefits of improvements to those forecasts. In large part, the purpose of this review was to identify the types of benefits that are either largest or easiest to use (or both), because these are the key types of benefits on which to focus in assessing the advantages of supercomputer acquisition.

Conclusions

Understanding and characterizing the economic values of hydrometeorological services can help build support for the services and increase the value of these services to society. The value of economic analysis will be enhanced when it is appropriately used and conducted. We call for the international hydrometeorological community to support valid and reliable economic research and assessments of the impact of and values for hydrometeorological services. There are a multitude of examples—based mostly on anecdotal evidence—of the use and value of hydrometeorological forecasts in a number of different sectors. In contrast, relatively few studies have used consistent and valid methods based on economic theory.

Undertaking better economic analysis requires as a minimum a better understanding of the impact of weather, water, and climate on society (not just on the *economy*). This does not require meteorologists to become experts in economics. Instead, it requires them to recognize that there is an art and science to economics (just as there is to meteorology) and that it is necessary to enlist the help of professional economists in undertaking studies of economic impacts. Collaboration of this nature is facilitated when meteorologists know enough about economics to understand what they want from economic studies—just as economists who work with meteorologists must have a basic understanding of weather and weather impacts and forecasts. We offer the economics primer as a step in developing this shared understanding.

Entraining economics into hydrometeorological activities also requires that the hydrometeorological community advocate funding for this work. Without money to support research and applications relevant to the hydrometeorological community, social scientists will work in other fields of interest where funding is available.

Some Useful Resources

We expect to make the primer available publicly at no cost in the very near future. We intend the primer to be a living document that will be revised, adjusted, and updated in response to the needs of users of the document. To learn more about resources on economics and hydrometeorological services, visit NOAA's Economics & Social Science (NESS) Web site at http://www.economics.noaa.gov. As an agency, NOAA focuses on the earth's physical sciences, but recognizes that interactions between earth science and social science are vital to its ultimate goal—giving users what they need. The NESS program and Web site is part of NOAA's Office of Program Planning and Integration (PPI). Another valuable resource can be found at http://www.sip.ucar.edu. NCAR, with funding from the U.S. Weather Research Program, established the Collaborative Program on the Societal Impacts and Economic Benefits of Weather Information (SIP) to create a dedicated focal point for assembling, coordinating, developing, and synthesizing research and information on the societal impacts and economic benefits of weather information.

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