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THE APPLICATION OF BAYESIAN METHODS IN BENEFIT TRANSFER

1. INTRODUCTION

Benefit transfer is a technique for measuring the benefits of environmental goods based on past information. In this chapter we focus on the application of Bayesian methods to the transfer method. Bayes' theorem involves the combination of prior information with sample information in order to derive a posterior distribution from which any inference can be made. Whereas classical approaches discard past statistical information on a random variable, the Bayesian approach updates prior beliefs and experiences in the light of new empirical information. Thus, Bayesian methods are particularly suitable to the transfer method. They can be utilized as a general framework in which prior information can be handled to obtain predictions on the value of new environmental goods or policy sites.

The application of a Bayesian approach to benefit transfer requires the definition of a prior distribution. This can be obtained from expert opinion or from past studies. Expert opinion is very valuable when there is little information on the potential benefits of a particular policy site. Prior distributions can be elicited from experts using elicitation methods. These methods are intended to derive the parameter of some specified model by relying on expert judgment and experience. Benefit transfer could be based on the elicited prior distribution. However, the application of Bayes theorem allows the researcher to update the prior distribution by utilizing some sample data from the new policy site. Thus, in a Bayesian framework, benefit transfer can be improved by considering the role of sample information in complementing the lack of past information. This means that sample information can be seen as substitute for past information on study sites. Therefore, on-site empirical studies could be reduced by the use of a Bayesian approach which incorporates past information or expert opinion.

In the next section we first outline the principal concepts involved in applying Bayesian methods to benefit transfer. Section 3 discusses some elicitation methods for obtaining the prior distribution from expert opinion. Sections 4 and 5 develops the likelihood function and the simulation methods utilized to obtain the posterior distribution. Section 6 outlines an experiment intended to elicit a prior distribution for a National Park in Spain. Section 7 presents the results of the elicitation experiment and compares them with those obtained from sample information. Finally, Section 8 discusses the main conclusions and the prospects for future research.

S. Navrud and R. Ready (eds.), Environmental Value Transfer: Issues and Methods, 227–239.

2. BAYESIAN METHODS

Bayesian methods provide an alternative statistical analysis of empirical data. The principal difference with respect to classical methods is the consideration of prior beliefs in the estimation of statistical and econometric models. That is, the application of Bayes' theorem (Bayes, 1763) allows the researcher to combine prior information with the likelihood obtained from empirical data. Whereas classical analysis discards prior beliefs and information, the Bayesian approach emphasizes the usefulness of past experiences in the estimation process. In this setting, prior beliefs are revised when new empirical observations are obtained.

Prior beliefs from expert opinion or past experience are summarized in the prior distribution. Let us consider that the researcher is interested in estimating parameter θ, which can be considered as the consumer surplus to be obtained from a new policy site. This can also be seen as a function of unknown parameters defining the distribution of willingness to pay. If there is some knowledge on the possible values to be obtained from the empirical study, this information can be represented with the specification of a prior density distribution $\pi(\theta)$. This contains the probability of observing the parameter θ before empirical data is collected, based on all available evidence from past experience. The prior distribution could also incorporate beliefs from expert opinion.

If data is collected from the new policy site, this will be useful to define a likelihood function $f(x \mid \theta)$, which represents the likelihood of obtaining the sample x given that the population behaves according to parameter θ. This sample information allows the researcher to update her prior beliefs by applying Bayes Theorem. That is:

$$(1) \qquad \pi(\theta \mid x) = \frac{\pi(\theta) f(x \mid \theta)}{\int_\Theta \pi(\theta) f(x \mid \theta) d\theta} \propto \pi(\theta) f(x \mid \theta).$$

This is the expression for the posterior distribution, which is derived by combining the prior distribution and the likelihood function, and where $\propto$ denotes proportionality. If sample information on the new policy site does not induce relevant changes in the prior distribution, then there is no need for on-site data collection. In this case the prior distribution could be compatible with the posterior. However, new data would be required if the prior distribution does not accurately predict the value of the new policy site. Thus, there is a trade-off between prior and sample information. The collection of on-site data can be particularly useful for increasing the accuracy and efficiency of benefit transfer, while reducing the costs of environmental valuation.

In benefit transfer, it is most useful to consider the predictive distribution. This gives the probability of observing new sample data, given past experience and sample observations. That is, the predictive distribution can be expressed as

$$(2) \qquad \mathrm{m}(\mathrm{y} \mid \mathrm{x}) = \int_\Theta \mathrm{f}(\mathrm{y} \mid \theta) \pi(\theta \mid \mathrm{x}) \mathrm{d}\theta,$$