# Annual Summary Report

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| **Period covered:** | Sept. 1, 2007 – Aug. 31, 2008 |
| **Date:** | Nov. 20, 2008 |
| **EPA Agreement #:** | RD-83346001-0 |
| **Title:** | *Meta-Analysis and Benefit Transfer at Different Levels of Aggregation: Comparing Group-Averaged and Individual-Level Models Using Hierarchical Bayesian Methods* |
| **Investigators:** | Klaus Moeltner (PI), Robert Johnston (Co-PI), Randall S. Rosenberger (Co-PI) |
| **Research Category:** | Economics and Decision Sciences |
| **Project Period:** | Sept. 1, 2007 – March 31, 2009 |

**Objectives**

The aim of this project is to compare Benefit Transfer results for resource valuation flowing from Meta-Regression Models with different levels of data aggregation. We hypothesize that conventional Aggregate Level Meta-Regression Models (ALMRMs) ignore underlying individual heterogeneity in preferences and behavior and thus understate the variability in expected benefits flowing from the transfer function. Avoiding this shortfall requires working with Individual Level Meta-Regression Models (ILMRMs) based on original data.

An added benefit from having access to original data is also the avoidance of data gaps in the ALMRM, since information on regressors not provided in printed outlets (which form the basis for an ALMRM) can be substituted using the original data. We label the resulting improved MRM the Enriched Aggregate Meta-Regression Model or EAMRM. In a nutshell, the main objective of the project is to compare the performance of the ALMRM, EAMRM, and ILMRM, using Bayesian hierarchical modeling techniques for maximum flexibility in data combination and generation of the BT function. We illustrate these techniques using simulated data and applications in outdoor recreation and land preservation.

**Progress Summary / Accomplishments**

Data Collection for Hiking Application

A total of 39 initial studies were identified for the hiking application by searching The Recreation Use Values Database hosted by Dr. Rosenberger at Oregon State University. The list was further refined to only include target studies that comprised individual travel cost data, resulting in a refined set of 17 candidate studies. Official letters requesting raw data were sent to the authors of these source studies. Raw data could be obtained for seven of these studies, including four data sets covering fire effects on hiking and mountain biking in the intermountain west; mountain biking in Moab, UT; and two nationwide recreation demand data sets aggregated by region.

Based on data quality and consistency the hiking data associated with evaluating the effects of fire on hiking use and value were selected as the most appropriate for model estimation. An additional benefit of focusing on original valuation studies with fire scenario component s is the option to develop interesting policy scenarios associated with prescribed burning for our BT exercise. The retained data were collected using similar surveys in five states (Colorado, Montana, Wyoming, Idaho, and New Mexico). The final pooled data restricted include 687 observations. This dataset is currently subjected to a final cleaning and will be ready for analysis shortly.

Data Collection for Land Preservation Application

The original candidate population of studies for the land preservation application were drawn from 18 choice experiment analyses of WTP for farmland preservation conducted in North America between 1996 and 2007. This set includes all choice experiments from the review of Bergstrom and Ready (2005) that allow for the direct calculation of willingness to pay values per acre of farmland preserved. Additional studies, including those drawn from the gray literature, were identified through: (1)

review of published research and bibliographies dealing with WTP for farmland preservation, (2) review of recent issues of resource economics journals, (3) searches of online reference and abstract databases (e.g., Environmental Valuation Resource Inventory (EVRI)) and (4) personal communication with authors known to have published research assessing farmland preservation or amenity values.

Starting from this population of candidate farmland studies, which were also analyzed in the aggregate data meta-regression model (MRM) of Johnston et al. (2008), the final metadata for the individual level MRM in the present case are limited to those in the original farmland valuation metadata for which original survey data could be obtained. This involved contacting original study authors and requesting copies of original coded data. This effort resulted in 11 unique data sets, eight corresponding to CE experiments conducted in separate communities in Delaware and Connecticut in 2005 and 2007, and three County-wide experiments conducted in Delaware in 2001. These datasets are ready for further analysis.

Model Simulations

To gauge the econometric challenges to be expected when working with actual field data we created a simulated individual-level meta-dataset, which was then subjected to estimation via an ALMRM and an ILMRM. For simplicity and in concordance with our hiking application we casted this exercise within an Incomplete Demand System (IDS) of outdoor recreation (e.g. LaFrance and Hanemann, 1989, LaFrance, 1990, Shonkwiler, 1999, Moeltner, 2003, Hagerty, 2005). To start, we assume there are $s = 1 \ldots S$ sub-populations of interest, each represented by an existing source study. Each study, in turn, covers $j = 1 \ldots J$ recreation sites, and contains trip information for $i = 1 \ldots N$ individuals. For our simulated data we set $S$ = 20, $J$ = 6, and $N$ = 200, which corresponds well to the typical sample size in existing recreation studies. We first generate three explanatory variables: income ($m$), travel cost (or "price") ($p$), and catch rate ($c$) as an example for a site quality indicator. These variables are drawn in a fashion that preserves the underlying hierarchical structure of "population" – "sub-population" – "individual" in their statistical properties. Second, we draw corresponding coefficients from a hierarchically structured sequence of densities. Combining these "true" parameter settings with our simulated data allows for the direct computation of seasonal trip demand and seasonal welfare.

We first estimate an ALMRM, which uses only site-aggregated data. Thus, it is based on a sample of $S * J = 120$ observations. The dependent variable is the visitor-averaged compensating variation associated with access to a given site. The dependent variables are user-averaged travel cost and income, and site-specific catch rate. We estimate a semi-log model and a log-log model, using the natural log for all regressors (after aggregation). To allow for heteroskedasticity and capture intra-study correlation with a single extension (see Moeltner et al., 2007) we specify a hierarchical distribution for the catch rate coefficients. We find that the log-log model ALMRM performs well and generates predicted benefits (at the mean of all regressors) that correspond closely to sample averages. We also estimate several ILMRMs with varying hierarchical structures, using structurally derived individual CV as dependent variable. As for the ALMRM, we consider a semi-log and a log-log form for our linear MRM.

In contrast to the ALMRM, virtually all attempted ILMRMs failed to generate benefit estimates of reasonable magnitude and range. Most suffered from serious identification problems for higher-level parameters. It became apparent that the customary linear MRM fails to capture the key features of the highly nonlinear functional form underlying the generation of the structural CV values. In other words, by switching from an aggregate to an individual-level estimation framework, we are also implicitly adopting the more complex and more highly nonlinear properties of the underlying theoretical model structure. This hampers the ability of a linear MRM to produce meaningful BT estimates, at least for our simulated application.

This crucial insight led us to a distinction between a *reduced-form* ILMRM (as considered in the original proposal) and a *structural* ILMRM, which we will examine more closely over the remaining grant period. Conceptually, the structural ILMRM would utilize the original data to directly generate welfare predictions for any desired BT context consistent with a common utility-theoretic framework. In

contrast, the reduced-form ILMRM proceeds in two steps: First, raw data are used to generate welfare estimates for each individual. Second, these estimates are then regressed against a set of explanatory variables (as needed for the BT function) in a standard linear meta-regression framework. In theory, the structural ILMRM should be more efficient than the reduced-form ILMRM as it avoids the second estimation step. However, its feasibility hinges crucially on the homogeneity of outcome variables employed in the original studies. We will examine the pros and cons of either specification of the next few months.

PI Meetings

Members of the grant team met twice during this first year. The first meeting between PI Moeltner and Co-PI Rosenberger took place at the Annual Meetings of the W2133 Regional Project ("Benefits and Costs of Natural Resources Policies Affecting Public and Private Lands ") in Kona, HI, Feb. 17-20, 2008. This meeting led to a refinement of the set of candidate studies / sources for the hiking application. The second meeting between PI and both Co-PIs took place in Reno, NV, August 9-12, 2008. During that meeting the grant team took a close look at the collected data sets for both applications and identified final cleaning steps for these data. The team also discussed the simulation results and corresponding methodological issues, especially the emerging distinction between reduced-form and structural ILMRMs.

**Publications / Presentations**

PI Moeltner presented preliminary simulation results at the W2133 Regional Project ("Benefits and Costs of Natural Resources Policies Affecting Public and Private Lands ") in Kona, HI, Feb. 17-20, 2008. The Power point slides for this presentation are available at the PI's Project web page at http://www.ag.unr.edu/moeltner/EPA_STAR.htm. Co-PI Johnston presented preliminary results of the land preservation ALMRM at the 2008 International Workshop on Meta-Analysis in Economics and Business, Nancy, France, Oct. 17-18, 2008.

**Future Activities**

For the remainder of the grant period PI Moeltner, with assistance of a graduate student, will estimate a variety ALMRMs and both types of ILMRMs for the hiking and land preservation applications. We are planning to present preliminary results at the 2009 Annual Meetings of the W2133 regional project in Austin, TX, Feb. 18-21. We are also currently preparing an abstract for a group session of the wider EPA Benefit Transfer research group at the 2009 AAEA Meetings in Milwaukee, July 26-28.

**Supplemental Keywords**

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| Media: | land |
| Public Policy: | public policy, nonmarket valuation, contingent valuation, public good, Bayesian, willingness-to-pay, conservation |
| Methods / Techniques: | modeling, analytical |
| Geographic Areas: | western, southwest, midatlantic, Delaware, DE, Connecticut, CT |
| Sectors: | agriculture |

**Relevant Web Sites**

The PI has opened a project web site at http://www.ag.unr.edu/moeltner/EPA_STAR.htm .

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