Systematic Variation in Willingness to Pay for Agricultural Land Preservation and Implications for Benefit Transfer: A Meta-Analysis

Jessica B. Kukielka
University of Connecticut

Robert J. Johnston
University of Connecticut

Joshua M. Duke
University of Delaware

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Presenting Author:
Jessica B. Kukielka
University of Connecticut
Department of Agricultural and Resource Economics
1376 Storrs Road
Storrs, CT 06269-4021
(860) 486-1929/ Facsimile: (860) 486-1932
Jessica.kukielka@gmail.com

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Jessica Kukielka is a graduate research assistant, Department of Agricultural and Resource Economics, University of Connecticut (jessica.kukielka@gmail.com).Robert J. Johnston is associate professor, Department of Agricultural and Resource Economics and associate director, Connecticut Sea Grant College Program, University of Connecticut. Joshua M. Duke is associate professor, Departments of Food and Resource Economics and Economics, and the Legal Studies Program, University of Delaware (duke@udel.edu). This research was funded by the National Research Initiative of the Cooperative State Research, Education and Extension Service, USDA, Grant # 2003-35400-13875 and by the Eastern Connecticut Resource Conservation and Development Area through an Agricultural Viability Grant from the State of Connecticut Department of Agriculture. The experimental design was completed by Lídia Rejtõ and Diccon Bancroft at the University of Delaware. Any remaining errors are those of the authors. Opinions belong solely to the authors and do not imply endorsement by the funding agencies.

Abstract

Despite prior studies examining willingness to pay for farmland preservation there has been no quantitative, systematic analysis of findings across the literature. This paper presents the first statistical meta-analysis of farmland preservation values. Results confirm systematic variations in willingness to pay, with value surfaces corresponding to theoretical expectations. Findings also provide significant insight into the potential for valid meta-analytic, function based benefit transfer. Results suggest, for example, that transfer validity is critically dependent on jurisdictional scale. Transfer errors are modest for community scale farmland preservation, but large for state scale preservation policies in which per acre welfare estimates are small.

Introduction

Over the past twenty years substantial research effort has been devoted to the assessment of farmland amenity values (Bergstrom and Ready 2005; Johnston and Duke 2008). A significant number of past assessments, for example, apply stated preference methods to quantify public willingness to pay (WTP) for farmland preservation. These studies investigate not only household values for preserving additional generic parcels of land (Halstead 1984), but also provide insight into voter priorities for attributes and amenities of preserved land (Bergstrom et al. 1985; Ready et al. 1997). Despite many case-study assessments of factors influencing WTP for the preservation of agricultural land, little is known about quantitative, systematic preference patterns that lead to WTP divergences across studies (Bergstrom and Ready 2003).

Knowledge of systematic variation in estimated farmland preservation values across studies and sites can provide a variety of insights into the potential use of applied welfare analysis for policy guidance. This insight can be particularly relevant for the use of benefit transfer to inform farmland preservation. Benefit transfer may be described as the "practice of taking and adapting value estimates from past research … and using them … to assess the value of a similar, but separate, change in a different resource" (Smith, van Houtven and Pattanayak 2002, p. 134). Although the use of primary research to estimate values is generally preferred, the realities of the policy process often dictate that benefit transfer is the only option for assessing certain types of non-market values (Rosenberger and Johnston 2007). The validity and accuracy of benefit transfers, however, depend on "the existence of a meta-valuation function from which values for specific issues can be inferred" (Rosenberger and Phipps 2007, p. 24). That is, valid transfer depends on systematic, robust patterns in the value surface across studies that allow WTP estimates to be transferred and adjusted based on differences between study and policy contexts (Bergstrom and De Civita 1999; Johnston et al. 2005).

Meta-analyses of existing non-market valuation studies—or more specifically meta-regression regression models (MRMs)—provide the primary means to assess the systematic patterns in WTP upon which function based benefit transfer depends (Johnston et al. 2005; Rosenberger and Phipps 2007). Recent works have given increasing attention to the potential use of MRMs to guide benefit transfer (Bergstrom and Taylor 2006; Johnston et al. 2005; Rosenberger and Stanley 2006). From the perspective of applied transfer, MRMs can serve two potential roles. First, they may be used to identify systematic influences of study, context, and resource attributes on WTP, as a precursor to benefit transfer conducted using other means (cf. US EPA 2007). Alternatively, MRMs may be used to generate reduced form benefit functions for direct use within function based benefit transfer (e.g., Bergstrom and Taylor 2006; Moeltner et al. 2007; Johnston et al. 2005, 2006a,b; Rosenberger and Johnston 2007; Shrestha et al. 2007; Rosenberger and Phipps 2007). There is widespread agreement on the suitability of MRMs for the former purpose, although there remain mixed opinions in the literature over the appropriateness of MRMs to estimate reduced form models for direct benefit estimation (cf. US EPA 2007; Rosenberger and Phipps 2007; Rosenberger and Johnston 2007).

Despite the increasing use of MRMs within the non-market valuation literature (e.g., Smith and Osborne 1996; Rosenberger and Loomis 2000a; Poe et al. 2001; Woodward and Wui 2001; Bateman and Jones 2003; Moeltner et al. 2007; Johnston et al. 2005, 2006a,b; Rosenberger and Johnston 2007; Shrestha et al. 2007), there has been no published meta-analysis addressing systematic patterns in WTP for farmland preservation. This omission is reflective of a broader lack of analyses related to the potential for benefit transfer to inform farmland preservation or broader agricultural policy (Johnston and Duke 2008). For example, despite the qualitative insight available from Bergstrom and Ready (2005) and unpublished work of Ozdemir et al. (2004), the authors are aware of only one published, quantitative assessment of function based benefit transfer applied to farmland preservation (Johnston and Duke 2008). Hence, notwithstanding insight available from existing work, the potential for accurate, reliable transfer of farmland amenity or preservation values remains largely unknown.

This paper describes the use of meta-analysis to examine systematic variations in welfare estimates derived from stated preference analyses of WTP for farmland preservation. The metadata are drawn from choice experiment analyses of WTP for farmland preservation conducted in North America. As the first statistical meta-analysis addressing WTP for farmland preservation, the paper examines both methodological issues related to the use of choice experiment results for benefit transfer, and empirical findings and policy implications. We also address the extent to which results justify the potential employment of MRMs for benefit transfer of farmland amenity values. This includes a detailed assessment of transfer error in various policy contexts and applications.

Results of the analysis are promising with regard to the ability of meta-analysis to synthesize information regarding WTP for farmland preservation and reveal systematic relationships unapparent from individual choice experiment studies. Results further suggest that WTP variation across prior choice experiment studies is largely systematic. Empirical findings also provide significant insight into the ability of MRMs to promote valid benefit transfers, particularly as influenced by attributes of the farmland preservation policy context.

Conceptual Framework for Meta-Regression Analysis

As the foundation for subsequent discussion, we begin with a simple conceptual model for MRM statistical analysis and function-based benefit transfer based on MRM results. As noted above, MRMs summarize relationships between welfare measures reported in studies and observable explanatory variables that contribute to the variation of these values (Bergstrom and

Taylor 2006). This statistical analysis allows the researcher to control for varying attributes between sample studies and account for these differences when applying benefit transfer estimates to a potential policy site (Shrestha et al. 2007).

MRMs are generally structured with at least weak correspondence to theoretical assumptions, where variables of study attributes, resource and context characteristics, and socio-economic factors are specified with respect to their expected impact on welfare measures (Smith and Pattanayak 2002; Bergstrom and Taylor 2006). Given the meta-data obtained from available studies, the one may specify the general functional relationship

$$WTP_{ij} = f\,(\boldsymbol{X_{ij}}, \boldsymbol{Z_{ij}}, \boldsymbol{B}) \tag{1}$$

where WTP_{ij} is the observed welfare estimate i from study j, $\boldsymbol{X_{ij}}$ and $\boldsymbol{Z_{ij}}$ are vectors of study site attributes and methodological study attributes, respectively, and $\boldsymbol{B}$ is a vector of parameters to be estimated (Johnston et al. 2006b).

Within the meta-analysis literature, equations such as (1) are parameterized and estimated using standard econometric methods. When used for benefits transfer, the application of the parameterized equation for WTP calculation and subsequent benefit transfer requires that the analyst assign values (i.e., choose variable levels) for $\boldsymbol{X_{ij}}$ and $\boldsymbol{Z_{ij}}$. Together with estimated parameters these allow WTP to be calculated for a given policy application and/or unstudied site. In contrast, value surface assessments (i.e., assessments of systematic patterns in WTP across observations) often involves assessments only of estimated parameters $\boldsymbol{B}$ relative to theoretical expectations or prior empirical findings. The following empirical analysis assesses both the potential for MRMs estimated following (1) to contribute to value surface assessments and to generate transferable benefit functions.

The Data

The applicability of meta-analysis to any particular research question is dependent on the quality and comparability of the available data (Johnston et al. 2005). Analysts must determine the optimal scope of the metadata (Rosenberger and Johnston 2007). The optimal scope may be nterpreted as the exact definition of the dependent variable in the meta-regression model which, in turn, defines the set of source studies to be considered for inclusion. The tradeoff is often between maintaining homogeneity among dependent variables versus including additional information (i.e., observations) in the metadata. Similarity, independent variable definition and study attributes within the metadata can be important for two reasons. First, theory may dictate that certain types of estimated values are not strictly comparable (e.g., Hicksian compensating surplus from a stated preference model versus Marshallian consumer surplus from a travel cost model). Second, model fit may be improved by narrowing the metadata; for example, to include only valuation studies that use a particular valuation approach (Rosenberger and Johnston 2007).

Potential issues relevant to study selection criteria may be framed in terms of a requirement that studies included in metadata satisfy both *commodity consistency* and *welfare consistency* (Bergstrom and Taylor 2006). The former implies that "the commodity (Q) being valued should be approximately the same within and across studies" (Bergstrom and Taylor 2006, p. 353). The latter implies that "measures of WTP within and across studies … should represent the same … welfare change measure, or ex-post calibrations [are] made to account for theoretical differences between welfare change measures" (Bergstrom and Taylor 2006, p. 355). Other considerations involve the tradeoff between the number of regressors or independent variables that may be included in a meta-regression analysis (*K*) and the number of studies that are appropriate to include in the metadata (*N*) (Moeltner et al. 2007).

The Metadata: Choice Experiments of Farmland Preservation Values

Choice experiments (CEs) ask respondents to evaluate alternative goods or programs that differ across a variety of attributes and choose the option that offers the greatest utility. Unlike contingent valuation—which typically estimates values for a single or very small number of policy or good configurations—CEs generate an empirical estimate of a utility function. This function allows analysts to estimate utility theoretic values for a wide range of policy or environmental good options and to assess how these values change when policy configurations are altered. The ability of CEs to adjust for differences in the attributes of environmental goods or policies provides an increased capacity to accommodate differences between study and policy sites—thereby improving the potential accuracy of benefits transfer (Morrison et al. 2002; Morrison and Bergland 2006; Johnston 2007).

These properties of choice experiments render the results of these models highly suitable for function based benefit transfer (Johnston 2007; Morrison et al. 2002; Morrison and Bergland 2006). Moreover, methodological homogeneity across contemporary choice experiments promotes valid pooling and comparison of study results within a meta-analytic framework, as it avoids complex influences of methodological heterogeneity that have confounded prior comparisons of farmland amenity values (Bergstrom and Ready 2005). For this reason, this study limits its focus to evaluation of choice experiment studies within the farmland preservation literature.

The metadata for the present analysis are drawn from 18 choice experiment analyses of WTP for farmland preservation conducted in North America between 1996 and 2007. This pool of studies represents all multi-attribute choice experiments (known to the authors) that allow for the direct calculation of willingness to pay values per acre of farmland preserved, based on standard, utility-theoretic methods. These include all relevant choice experiments referenced in the review of Bergstrom and Ready (2005), in addition to additional grey literature and other studies published subsequent to this review. Additional studies 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)); (4) personal communication with authors known to have published research assessing farmland preservation or amenity values. Studies were drawn from peer-reviewed journal articles, theses/dissertations, and technical/government reports. Unpublished conference proceedings and presentations, however, were not included.

Although the metadata include observations from all published choice experiment analysis of North American farmland preservation values, the number of such studies is limited. However, given the capacity of choice experiments to forecast welfare estimates for a wide range of preservation options—characterized by differences in multiple preservation attributes—each study in the metadata provides numerous observations of WTP. The availability of multiple observations per study is common for meta-analysis in the valuation literature (cf. Bateman and Jones 2003; Poe et al. 2001; Johnston et al. 2005, 2006b). Table 1 characterizes the final 18 studies selected for this analysis. From these studies, 1592 observations are available, averaging 88 observations per study.

The dependant variable for the meta-analysis is a monotonic function of WTP per acre, per household, per year for farmland preservation (see details below). In a small number of cases, estimates of WTP per acre for some or all observations are provided by study authors (e.g., Johnston, Duke and Kukielka 2007). However, in the majority of cases WTP per acre was calculated directly from parameter estimates and other data provided by the original studies, following standard approaches for choice experiments (e.g., Boxall et al. 1996).

Independent variables included in the meta-analysis are derived from a list of attributes with potential influence on WTP for farmland preservation, based on theory and prior findings in the empirical literature. These include variables characterizing farmland attributes, preservation context and methods, socioeconomic (population) variables, and methodological (study) attributes. Variable definitions and descriptive statistics are provided in table 2. As emphasized by Johnston et al. (2005), meta-analysis almost universally requires reconciliation of variables and attribute levels across observations. Here, most reconciliations are straightforward, as detailed in table 2. However, as in most meta-analyses (e.g., Johnston et al. 2005), a small number of variables warrant additional interpretation.

For example, public access levels were grouped into three mutually exclusive categories – no access, moderate access, and high access. An observation was assumed to offer no access if the lack of public access was specifically noted in the survey scenario, or if public access was not mentioned as a possibility. The moderate access category included observations in which surveys specified either some form of passive recreational access (e.g., walking, hiking, etc.) or in which access permitted in a restricted manner (e.g., only on a portion of preserved acres). The high access category, in contrast, included observations characterized by non-passive access (e.g., hunting or motorized access), or in which access is otherwise unrestricted (table 2).

Other variables that warrant explanation include those characterizing preserved land types. Original studies in the metadata address a substantial variety of land types; many of which are similar (e.g., different types of crop or livestock farms). To reduce the number of occasions in which a land type dummy variable distinguished only a single study, farmland types were assigned to aggregate groups. These assignments were based largely on the land cover, aesthetic and other properties of farmland. For example, the variable *forest* reflects land characterized as in forestry, orchard, or tree-farm land use. Other categorizations and variable definitions are detailed in Table 2.

The Empirical Model

Past meta-analyses have incorporated a range of statistical methods, with none universally accepted as superior (Johnston et al. 2006a). Prior MRMs, however, often apply semi-log, log-linear, trans-log, or other forms involving log transformations of either dependent or independent variables (Johnston et al. 2005). Advantages of such functional forms can include improved fit to the data and empirical properties that better coincide with theoretical expectations (e.g., Johnston et al. 2005). The current metadata, however, include numerous instances of non-positive WTP estimates. Because log functional forms are undefined at zero and negative values, the use of such forms would require *ad hoc*, arbitrary adjustments of the dependent variable (Layton 2001).

To avoid potential biases associated with such arbitrary adjustments, but retain desirable properties of non-linear functional forms, an alternative transformation – the inverse hyperbolic sine (Burbridge et al. 1988) – is applied to the econometric model. As described by Burbridge et al. (1988), the inverse hyperbolic sine transformation (IHS) offers a potential modeling solution for data sets containing both positive and negative values, but for which analysts wish to approximate log curvature in estimated relationships.[1] The IHS is a flexible family of curves; symmetric and linear around the origin and approximating a logarithm in the right tail (Layton 2001; Pence 2006). Because the log-likelihood function for the IHS is defined for zero and negative values of the dependant variable, however, this transformation eliminates the need for *ad hoc* adjustments to welfare values. The first application of the IHS model transformation in

[1] Another transformation that has been considered for handling extreme or negative dependant variable values is the standard Box-Cox transformation, $(x^k - 1)/\lambda$. However, as discussed by Burbridge et al. (1988) and Layton (2001), this function cannot be estimated as λ approaches zero. In our data, and in similar valuation studies, there are variables with values of zero or near-zero. Therefore, this function alternative is not applicable for our purposes.

the non-market valuation literature is provided by Layton (2001), who illustrates the potential advantages of this function form for stated preference estimation. The following application, however, is the first application of the IHS form to valuation meta-analysis.

The general IHS form can be written as:

$$g(x, \theta) = \ln(\theta x + (\theta^2 x^2 + 1)^{1/2}) / \theta = \sinh^{-1}(\theta x) / \theta \qquad (2)$$

where x is the variable to be transformed and θ is a scaling parameter. The function g(x, θ) is symmetric around zero in θ, and typical generalizations of the formula concentrate on values of θ ≥ 0 (Burbridge et al. 1988). As noted above, the transformation is linear when θ approaches zero and behaves logarithmically for larger values of θ (Burbridge et al. 1988; Pence 2006). The standard IHS transformation (cf. Layton 2001) sets θ=1, such that (2) simplifies to

$$G(x \mid \theta=1) = \ln(x + (x^2 + 1)^{1/2}) = \sinh^{-1}(x) \qquad (3)$$

In the present case, the standard IHS transformation was applied both to the dependent variable (per acre WTP), and to the explanatory variable characterizing jurisdiction acreage. All other independent variables are linear, leading to a trans-IHS functional form (cf. Layton 2001). Other than the use of the IHS functional form, the econometric model follows standard conventions for meta-analysis; the MRM is estimated as a multi-level model using maximum likelihood estimation with White-corrected standard errors to correct for heteroscedasticity and serial correlation across observations (Rosenberger and Loomis 2001; Bateman and Jones 2003; Johnston et al. 2005). Following Johnston et al. (2005, 2006a), both weighted and non-weighted regression results are illustrated, with weights for the former model defined following Poe et al.

(2001), such that the sum of weights for all observations from a given study is equal to one.[2]

Econometric Results

Model results are displayed in table 3. Model 1 is the unrestricted, unweighted model. Model 2 is the weighted version of the unrestricted specification. Likelihood ratio tests indicate that model variables are jointly significant at $p<0.0001$ in both instances (-2 Log Likelihood χ^2 = 1084.96, df = 25 for the unweighted model and χ^2 = 809.91, df=25 for the weighted model). R^2 values computed from ordinary least squares (OLS) variants of the reported models[3] suggests that the estimated models account for a significant proportion of variance in WTP values across observations, particularly as compared to prior meta-analyses in the literature (cf. Johnston et al. 2006a). Random effects are not statistically significant in either estimated model. Initial comparisons between the two models indicate that parameter estimate magnitudes and significance levels are robust to weighted versus unweighted model specifications. This corresponds to findings in prior meta-analyses (e.g., Johnston et al. 2005, 2006a).

Value Surface Tests

Empirical results provide clear evidence of value surfaces that correspond to prior findings and theoretical expectations. Of 26 parameter estimates in the model, 20 are statistically significant at $p<0.10$ or better. Revealed empirical patterns in WTP across studies and observations suggest the presence of an underlying meta-valuation function or value surface

[2] The literature has not reached consensus over the use of weighted versus unweighted models. Weighted specifications prevent studies that provide multiple observations from unduly influencing model estimation, but also imply that such studies are no more informative, overall, than others (Bateman and Jones 2003). Given the lack of consensus, both specifications are illustrated here.

[3] Maximum Likelihood random effects models do not provide standard R^2 estimates. Therefore, these reported estimates should be evaluated with caution, as they serve as only approximates of the variations explained by the model.

(Rosenberger and Phipps 2007) upon which defensible benefit transfers might be grounded.

For example, empirical results suggest that WTP values are sensitive to both scope (i.e., the quantity of land preserved) and scale (i.e., the size of the jurisdiction within a given amount of land is preserved), extending similar meta-analytic findings for other resource types (e.g., Smith and Osborne 1996; Johnston et al. 2005, 2006a). In this case, larger preserved areas are associated with lower WTP/acre values. Relative to the default case in which less than 1000 acres are preserved, WTP/acre is successively smaller for preservation acreages between 1000 and 10,000 acres (*Acres_1to10k*) and over 10,000 acres (*Acres_10kplus*). These findings reflect expected patterns of diminishing marginal utility of preservation. Results also suggest a negative influence of jurisdiction size (*IHSarea*) on WTP/acre, validating prior small sample findings of Johnston and Duke (2008). For example, one might expect lower WTP/acre when farmland is preserved somewhere within a respondent's home state compared to otherwise identical preservation implemented somewhere within a respondent's home community, in part because of the lesser degree of expected proximity to preserved land preserved within larger jurisdictions and reduced expectations of use values (Johnston and Duke 2008).

Model results also validate the findings of some earlier valuation studies that predominant land use can influence WTP for preservation, but that land type may not be a dominant consideration in some contexts (Johnston and Duke 2007, 2008; Bergstrom and Ready 2005). For example, the significant and positive coefficient on prime farmland soils is consistent with earlier findings that higher WTP may be associated with such productive soil types (Bergstrom et al. 1985), while the lack of statistical significance for the majority of land type parameter estimates also corresponds to prior findings that farmland type may not always be significant determinant of welfare impacts (e.g., Johnston and Duke 2007).

Results also validate prior single-study findings that preservation methods can exert statistically significant influences on WTP (Johnston and Duke 2007, 2008). For example, relative to the default of zoning or regulatory methods, WTP/acre is greater for preservation accomplished using government conservation easements (*s_t_con*), land trust conservation easements (*trust_con*), or land trust outright purchase (*trust_pur*); all these effects are statistically significant. However, results do not suggest a statistically significant difference in WTP between regulatory methods and outright purchase by government agencies (*s_t_pur*).

Considering expectations based on prior findings (Duke et al. 2002; Bergstrom and Ready 2005; Johnston and Duke 2007, 2008), public access has a large and highly significant effect on WTP, with moderate access more highly valued than other access alternatives. Preservation offering no access is the least preferred. Preservation offering non-passive "high" access – such as hunting or four-wheeling – is preferred to no access, but not preferred to moderate levels of access. Such patterns in public preferences for access mirror findings in prior research both in the farmland and non-farmland literature (e.g., Johnston et al. 2002; McGonagle and Swallow 2005; Johnston and Duke 2007, 2008). Specifically, prior research often finds that public access is associated with statistically significant welfare improvement, but that welfare gains are greatest for moderate—as opposed to more extensive—levels of access.

Value surfaces related to policy context—including the presence of potential substitutes and complements—also follow theoretical expectations. For example, empirical results suggest that WTP/acre is greater for preservation that occurs in more densely-populated jurisdictions. This is an expected pattern related to the perceived scarcity of farmland in densely populated areas. Similarly, indicators of population growth, development rates and risk of development are associated with systematic increases in WTP. Interestingly, preservation programs targeting urban areas are associated with lower WTP values. A possible explanation for this result is that farmland in a densely-populated area may be viewed as ill-placed or less viable than larger agrarian communities away from urban centers.

In contrast to the statistically significant results associated with context and resource attributes, population characteristics do not demonstrate significant impacts on WTP. The effect of income is statistically significant but counterintuitive in sign (negative). The reason for this finding is unknown, but is robust across various model specifications. While these results might suggest that, perhaps, farmland is considered an inferior good, it is also possible that these results are due to either measurement error in the income variable or unintended correlation between income and other excluded factors. The income variable was calculated using census data from a base of year 2000 dollars; an instrument chosen because adequate measures of respondents' income and education levels were not available from all source studies. The census-based income instrument, therefore, is subject to a measurement error in defining respondent incomes. It is also possible that lower-income jurisdictions may be associated with systematic preference or land use patterns that are not otherwise captured in the model specification.

Finally, as found in numerous prior meta-analyses and discussed by Johnston et al. (2006b), Moeltner et al. (2007) and others, results indicate systematic variation of WTP associated with methodological attributes of study implementation and design. These results imply that the ways in which stated preference surveys are implemented can have a direct impact on welfare estimates. Specifically, this analysis finds that both year of survey implementation and the method of distribution have statistically significant impacts on public values estimates.

Benefit Transfer Performance

Although there is widespread agreement concerning the ability of MRMs to illuminate relevant value surface patterns, there is less consensus regarding the direct use of such models for benefit estimation and transfer. While some caution against the direct application of meta-analysis for welfare estimation (e.g., Poe et al. 2001, US EPA 2007) other researchers note the potential of MRMs to provide reduced error benefit transfers in many policy contexts (e.g., Johnston et al. 2005; Moeltner et al. 2007; Rosenberger and Phipps 2007; Shrestha et al. 2007). The following section characterizes the magnitude of transfer errors that might result from the current MRM, based on leave-one-out, cross-validation tests of transfer error (cf. Layton 2000; Stapler and Johnston 2007).

To illustrate the cross-validation convergent validity test, assume that one has metadata with n=1…N unique observations. The first step in the leave-one-out testing framework is the omission of the nth observation from the metadata, which is the same as a hold-out sample comprised of a single observation. The MRM is then fitted (i.e., parameters are estimated) using the remaining N-1 observations. This is then iterated for each n=1…N observation, resulting in a vector of N unique parameter estimates, each corresponding to the omission of the n^{th} observation (Efron and Tibshirani 1993). For each n=1…N observation, the n^{th} observation is not part of the metadata during estimation of the n^{th} model iteration, and is hence an out-of-sample observation corresponding to the vector of parameter estimates resulting from that iteration.

Parameter estimates for the n^{th} model iteration are then combined with independent variable values for the n^{th} observation (omitted in that model iteration) to generate a WTP forecast for the omitted, and hence out of sample, n^{th} observation. As MRM results are only used to forecast WTP for the nth observation omitted from each estimated model, the result is N out-of-sample WTP forecasts, each drawn from a unique MRM estimation. Transfer error is assessed through comparisons of the predicted and actual WTP value for each N observations.

Following common convention, transfer error is quantified as a percentage divergence of transfer estimates from the actual study site value for each observation (Rosenberger and Stanley

2006). Percent errors in WTP/acre are presented as an average absolute value over all *N*=1592 observations. Results are presented as trimmed means (5%) to offset the effects of a small number of outliers. These occur in relatively rare instances of near-zero actual WTP estimates, such that even very small magnitude transfer errors represent very large, outlying percentages.

Cross-validation transfer results for the full model are displayed in table 4 (full-sample model). Results are disaggregated by the political jurisdictional size of corresponding observations (community, county, state). As shown by table 4, transfer error varies markedly across jurisdictional sizes, with community-level transfers universally and substantially out-performing state transfers. Community scale transfer errors vary from 20.02% in Georgetown, DE to 94.94% in Preston, CT; these results suggest reasonable transfer performance relative to past results in the literature (Rosenberger and Stanley 2006), and results that might be suitable for applied use depending on the level of welfare precision required. They are also similar in magnitude to site-to-site function based transfer errors for farmland preservation values estimated by Johnston and Duke (2008).

In contrast, state scale errors range from 1887.21% to 33,262.36%, implying transfers are likely unacceptable for applied welfare estimation. These poor state scale results suggest difficulty in accurately predicting small magnitude WTP values. Moreover, transfer errors are larger in percentage terms when compared to smaller state scale baseline values. In the state of Georgia, for example, mean WTP varied from $0.00005 to $0.0002 per acre (Ozdemir 2002; Volinsky and Bergstrom 2004). State studies produce small per acre welfare values, in part, because preservation options presented in state scale survey scenarios often reflect large acreages. As a result, per acre WTP estimates are small, at least in part due to diminishing marginal utility of preservation (cf. Johnston and Duke 2008).

Split-Sample Models

The relatively poor performance of state scale transfers raises the question regarding the appropriateness of pooling observations from different jurisdictional scales within a single MRM. To assess this possibility, we split the metadata into two subsets—one including only state scale observations and another including only community and county observations. Independent, split-sample MRMs are estimated for each dataset, with out-of-sample transfer errors again estimated as detailed above. As above, the MRM is estimated as a multi-level model using maximum likelihood estimation with White-corrected standard errors, with a trans-IHS functional form. Unweighted model results are illustrated.

The state scale metadata includes 644 observations from seven studies. Relative to the unrestricted, pooled model, seven independent variables were omitted due to lack of sufficient variation within the state sample, insufficient degrees of freedom (particularly for dummy variables whose values are constant across all observations from one or more studies), or lack of statistical significance. Similar restrictions were used to specify a community and county split-sample model. This latter metadata includes 11 and 948 observations, with four independent variables omitted due to lack of variation, degrees of freedom, or statistical significance.

Split sample MRM results are displayed in table 5. Although coefficient magnitudes vary across models as expected, signs and significance are largely (but not universally) consistent across models, and also generally consistent with findings from the unrestricted model (table 3). Value surface assessments for statistically significant parameters broadly correspond to the intuition detailed above, suggesting that qualitative model implications are largely robust to varying model specifications (i.e., split-sample versus pooled). Specification differences between the pooled and split-sample models, however, prevent formal use of nested likelihood ratio tests to assess the validity of restrictions implied by the pooled model.

The general robustness of parameter signs and significance is promising sign applied uses of meta-analysis, as it suggests that analyst choices regarding required levels of homogeneity in metadata may not lead to substantial variation in value surface implications. The primary purpose of the split-sample estimation in this case, however, is to assess implications for benefit transfer accuracy—particularly for applications to state scale observations. To assess implications for transfer error, cross-validation transfer assessments were also performed for each split-sample model following the procedures described above. The results of the split-sample cross-validation transfers are presented in the final column of table 4 (split sample model). Absolute value percentage errors are presented in comparable form to those of the full sample model.

Implications of the split-sample models for transfer error are mixed. Compared to results from the full model, split sample transfer errors are reduced for all state jurisdictions, and in some cases by large margins. For example, mean absolute value transfer errors in Connecticut drop to between 70.45% and 125.84%, from full sample values greater than 1800%. In other cases state scale transfer errors remain large, but are nonetheless reduced greatly from full sample model levels. That is, for state scale benefit transfers, transfer errors are improved when the metadata are limited to state scale study sites. Nevertheless, it is also important to note that despite these improvements, transfer errors for states often remain high compared to prior findings in the literature (Rosenberger and Stanley 2006). Results of the split-sample MRM are mixed for community scale transfers, with transfer errors reduced in four out of eight cases. County-scale transfer errors, however, universally increase in the split-sample model (table 4).

Despite acknowledged requirements that metadata satisfy commodity and welfare consistency in tandem (Bergstrom and Taylor 2006), comparison of split-sample and full model transfer errors indicates that increased homogeneity within the metadata will not necessarily improve transfer errors. As a result, analysts may wish to exercise caution when omitting observations or splitting samples in order to impose greater homogeneity in metadata observations. In addition to risking a magnification of selection biases (Rosenberger and Johnston 2007), such practices may diminish transfer performance in some cases. Moreover, results provide minimal evidence that value surface insights are enhanced within the split-sample models.

Conclusions

This paper illustrates the first statistical meta-analysis of WTP for farmland preservation. Data are drawn from choice experiments allowing estimation of WTP per acre for multi-attribute farmland preservation in various states and at different jurisdictional scales. The model also illustrates the first use of the inverse hyperbolic sine (IHS) functional form for meta-analysis within the valuation literature. Results demonstrate the capacity of MRMs to both characterize value surfaces associated with farmland preservation and generate reduced form models for benefit transfer. The model is designed to both provide insight into the potential use of MRMs to inform farmland preservation policy and provide a formal assessment of benefit transfer performance. For the latter assessments, performance is evaluated through repeated leave-one-out, cross-validation (out of sample) tests of transfer error – a more rigorous approach than is typically applied by the benefit transfer literature.

The analysis offers a range of findings of potential relevance to welfare analysis. Results suggest the presence of a meta-valuation function that can be used as a conceptual foundation for benefit transfer of farmland preservation values, and provide numerous insights into the associated value surface. Assessments of underlying WTP measures suggest construct validity in estimated values across observations. Benefit transfer performance, however, is mixed.

Comparative results for state and community scale transfers data suggest that transfer errors are dependent on jurisdictional scale, with community scale transfer errors substantially smaller than comparable state scale errors. While the magnitude of transfer errors for community scale observations suggests the possibility for policy applications in cases where broad welfare guidance is desired, the magnitude of state scale transfer errors would likely preclude applied policy uses. Models splitting the metadata by jurisdictional scale do not offer unambiguous improvements in transfer performance over that found in the full sample MRM.

Overall, model results are promising with regard to the ability of MRMs to identify components of systematic variation of WTP values and reveal patterns unapparent from stated preference models considered in isolation. Nevertheless, potential transfer errors in some cases may exceed acceptable limits. The results of this study indicate that meta-regression benefit function approaches can provide important information to guide potential policy programs. Additional work, however, is required to provide evidence regarding the suitability of MRMs for direct benefit transfer applications.

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TABLE 1.
METADATA STUDIES AND SOURCES

Author (Year of Study)	No. of Obs. in Meta-analysis	Target Location of Study	Type of Publication (Citation Year)	Study Methodology	Mean WTP Values*	Range WTP Values*
Duke, J.M. and T.W. Ilvento (2001)	12	Kent County, DE	Published Paper (2002)	Tobit	0.00752	0.000402 to 0.04944
Duke, J.M. and T.W. Ilvento (2001)	12	Sussex County, DE	Published Paper (2002)	Tobit	0.00548	-0.00509 to 0.04475
Duke, J.M. and T.W. Ilvento (2001)	12	New Castle County, DE	Published Paper (2002)	Tobit	0.00843	0.00172 to 0.05156
Johnston, R.J., J.M. Duke, (2005)	180	State of Connecticut	Published Paper (2007)	Mixed/ Multinomial Logit	0.00231	-0.00742 to 0.01047
Johnston, R.J., J.M. Duke, (2005)	180	State of Delaware	Published Paper (2007)	Mixed/ Multinomial Logit	0.00269	-0.01388 to 0.01681
Johnston, R.J., J.M. Duke, J.B. Kukielka. (2007)	48	Town of Woodstock, CT	Report/technical Paper (2007)	Conditional Logit	0.13309	-0.67209 to 1.47731
Johnston, R.J., J.M. Duke, J.B. Kukielka. (2007)	48	Town of Brooklyn, CT	Report/technical Paper (2007)	Conditional Logit	0.15849	-0.33166 to 1.35352
Johnston, R.J., J.M. Duke, J.B. Kukielka. (2007)	48	Town of Pomfret, Ct	Report/technical Paper (2007)	Conditional Logit	0.20122	-0.01968 to 1.03707
Duke, J.M., R.J. Johnston, T.W. Campson (2005)	48	Town of Thompson, CT	Report/technical Paper(2007)	Conditional Logit	0.08567	-0.54722 to 1.00448
Duke, J.M., R.J. Johnston, T.W. Campson (2005)	180	Kent County, DE	Report/technical Paper (2007)	Mixed/ Multinomial Logit	0.16118	-0.31917 to 1.09351
Johnston, R.J. J.M.Duke, T.W. Campson (2005)	180	Sussex County, DE	Report/technical Paper (2007)	Mixed/ Multinomial Logit	0.24621	0.08889 to 1.08965
Johnston, R.J., J.M. Duke, T.W. Campson (2005)	180	Town of Preston, CT	Report/technical Paper (2007)	Conditional Logit	0.17253	-0.56964 to 1.41298
Johnston, R.J., J.M. Duke, T.W. Campson (2005)	180	Town of Mansfield, CT	Report/technical Paper (2007)	Conditional Logit	0.26512	-0.36533 to 1.47761
Johnston, R.J., J.M. Duke, T.W. Campson (2005)	180	State of Connecticut	Report/technical Paper (2007)	Conditional Logit	0.00537	-0.00811 to 0.01935
Ozdemir, S. (2002)	24	State of Georgia	Thesis (MS) (2003)	Conditional Logit	9.672E-05	-0.00032 to 0.00071
Ozdemir, S. (2002)	24	State of Ohio	Thesis (MS) (2003)	Conditional Logit	9.141E-05	-0.00036 to 0.00059
Ozdemir, S. (2002)	24	State of Maine	Thesis (MS) (2003)	Conditional Logit	0.00013	-0.000241 to 0.000863
Volinskiy, D., J.C. Bergstrom (2002)	32	State of Georgia	Report/technical Paper (2004)	Mixed/ Multinomial Logit	3.639E-05	0 to 0.00062

* WTP Values reported as per acre per household per year

TABLE 2.
EXPLANATORY VARIABLES: DERIVATIONS AND ASSUMPTIONS

Variable	Description	Mean (St. Dev)
WTP**	WTP per acre, per household, per year. Calculated based on given coefficients in each study or reported MWTP values within study publications	0.289521 *(0.399603)*
IHS_WTP	A transformation of WTP values according to the inverse hyperbolic sine, such that the transformation equals: log(wtp + sqrt(wtp^2 +1))	0.108662 *(0.154255)*
No_obs**	Number of observations within each study. This value represents the total number of WTP estimates provided by the information in each study.	150.251 *(55.6187)*
No_obs_inv	Inverse of the number of WTP observations in each study. Provided as the weight in the weighted model specification.	0.010050 *(0.009230)*
IHSarea	A transformation of jurisdiction size according to the inverse hyperbolic sine, such that the transformation equals: log(area_ac + sqrt(area_ac^2 +1))	13.63609 *(4.54475)*
Acres_avg**	Average number of acres specified to survey participants; accounts for the average size of parcels upon which WTP values are based.	24108.57 *(156256.5)*
Acres_1to1K*	A binary variable indicating if the average acres presented in each study is 1000 acres or less. (1=acres_avg<1001, 0=acres_avg>1000)	0.623832 *0.484565)*
Acres_1to10K	A binary variable indicating if the *Acre_avg* to be preserved in the study is greater than 1000 but less than 10,000 acres. (1=1000<acres<10000, 0= acres>10000, acres<1000)	0.339196 *(0.464819)*
Acres_10Kplus	A binary variable indicating if the average acres presented in each study is 10000 acres or greater. (1=acres_avg>10000, acres_avg<10000)	0.065327 *(0.238936)*
Urban	A binary variable indicating if the parcel in question is specified as being located in an urban area (1=urban; 0=rural or unspecified)	0.032663 *(0.171664)*
Prime	A binary variable indicating that the parcel in question is identified as containing prime agricultural soils (1=prime soils indicated; 0= no specification)	0.032663 *(0.171664)*
Unspec_multi	A binary variable indicating that the study did not specify a unique landtype in the choice questions (1=landtype is unspecified, 0= one landtype is defined)	0.013819 *(0.161748)*
Lvstck	A binary variable indicating the that land is specified as dairy, livestock, or crop-based food (1=livestock/food landtype for specific parcel, 0=other)	0.316583 *(0.461972)*
Idle	A binary variable indicating the that land is specified as idle, hay fields, or open space (1=idle/fields landtype for specific parcel, 0=other landtype)	0.221106 *(0.414114)*
Forest	A binary variable indicating the that land is specified as forestry, orchard, or tree-farm land use (1=forest/tree landtype for specific parcel, 0=other landtype)	0.251256 *(0.431781)*
Nursery*	A binary variable indicating the that land is specified as nursery production (1=nursery landtype for specific parcel, 0=other landtype)	0.197864 *(0.387594)*
Trust_pur	A binary variable indicating that the preservation option uses private funding (i.e. trusts) to purchase the parcel (1=trust outright purchase method, 0=other method)	0.113065 *(0.306824)*
Trust_con	A binary variable indicating that the preservation option uses private funding (i.e. trusts) to apply contracts or easements to the parcel (1=trust contracts, 0=other method)	0.113065 *(0.306824)*
S_t_pur	A binary variable indicating that the preservation option used public (state or town) funding to purchase the parcel(1=Public-funded outright purchase, 0=other method)	0.263819 *(0.449313)*
S_t_con	A binary variable indicating that the preservation option used public (state or town) funding to apply an easement to the parcel (1=Public contracts, 0=other method)	0.351759 *(0.480762)*
Zone*	A binary variable indicating that the specific parcel will be preserved through changes in zoning regulations (1=zoning method of preservation, 0=other method)	0.158292 *(0.35441)*

No_high*	A binary variable indicating that the parcel is not at high risk for development within 10 years (includes low, moderate, or unspecified risk) (1=not high risk, 0=high risk)	0.667714 *(0.462214)*
H_risk	A binary variable indicating that the specific parcel is at high risk for development within 10 years (1= high development risk, 0=not high risk)	0.332286 *(0.462214)*
No_access	A binary variable indicating that the parcel will not be accessible to the general public after preservation (1=no access available, 0=accessible)	0..318925 *(0.466196)*
Moderate_access	A binary variable indicating that the parcel will be accessible for passive recreational activities after preservation (1= moderate access, 0=not accessible or high access)	0.301402 *(0.459001)*
High_access*	A binary variable indicating that the parcel will be accessible for high active recreational activities, such as hunting, after preservation (1= high access , 0=not high access)	0.245327 *(0.430407)*
Inc_pop	Median Population income level as reported in the 2000 U.S. Census for each jurisdiction	48330.59 *(6582.304)*
Edu	Percent of the population over the age of 25 with a Bachelor's degree or higher, as reported in the 2000 Census	27.7929 *(10.5624)*
Response_rate	Deliverable survey response rates as reported by the study authors (i.e. percent responded)	39.7798 *(12.2579)*
Growth_pop	Reported as the percent change in population over the years from 1985 to 2000 of U.S. Census data.	23.8081 *(15.5991)*
Area_ac**	Size of jurisdiction reported in acres	3052052.98 *(7534730)*
Density_hh	Housing density reported as the number of housing units per square mile within the jurisdiction, based on 2000 U.S. Census	133.4861 *(87.991)*
Percent_preserved	Percent of the total land area that is preserved through contracts, purchasing, and other preservation methods (As of 2000).	16.1089 *(8.9184)*
Mlogit	A binary variable indicating that the study methodology used to calculate WTP values was a mixed or multinomial logit. (1=mlogit, 0=other method)	0.359296 *(0.471817)*
Region_south	A binary variable indicating that the study took place in the South Atlantic region of the U.S.; regions were defined according to the U.S. Census (1=south, 0= other region)	0.396985 *(0.482718)*
Year	An index variable indicating the year in which the survey was implemented. The index is based on the difference of the study year and the reference year 1995 (Range: 1-12)	9.954774 *(2.561325)*
Method_person	A binary variable indicating the method in which the surveys were implemented. (1=in-person; 0=mail=in)	0.022613 *(0.143519)*

*Indicates default in defined model; summaries presented in this table are included to clarify variable specifications
**Indicates a specified variable that Is used in a subsequent calculation of variables within the specified model.

TABLE 3.
META-REGRESSION ANALYSIS RESULTS: WEIGHTED AND UNWEIGHTED MODELS

Variable	**Model One: Unweighted** (t-statistic)	**Model Two: Weighted** (t-statistic)
Intercept	2.9171*** (9.83)[a]	2.7533*** (5.41)
Acres_1to10k	-0.3569*** (-8.05)	-0.3442*** (-6.54)
Acres_10kplus	-0.7245*** (-9.30)	-0.6706*** (-8.43)
IHSarea	-0.04166*** (-5.54)	-0.03585** (-2.41)
Prime	0.000212*** (3.13)	0.000226*** (3.62)
Lvstck	0.1036* (1.74)	0.1030* (1.81)
Forest	0.09351 (1.42)	0.07054 (1.18)
Idle	0.07873 (1.41)	0.07964 (1.48)
Unspec_multi	0.09411* (1.69)	0.09031* (1.65)
Trust_pur	0.1142** (2.48)	0.1143** (2.48)
Trust_con	0.07091** (2.06)	0.0701** (2.06)
S_t_pur	0.06646 (1.20)	0.06985 (1.27)
S_t_con	0.1129** (2.06)	0.1095** (1.99)
H_risk	0.06772** (2.43)	0.09034** (2.36)
No_access	-0.2103*** (-3.98)	-0.2621*** (-4.75)
Moderate_access	0.2295*** (3.24)	0.2813*** (4.19)
Inc_pop	-7.5E-6** (-2.34)	-6.43E-6* (-1.72)
Edu	-0.00136 (-1.09)	-0.00064 (-0.41)
Urban	-0.00012** (-2.04)	-0.00013** (-2.43)
Response_rate	0.007554*** (3.40)	0.006315*** (3.27)
Density_hh	0.000461*** (2.80)	0.000265*** (2.64)
Growth_pop	0.006755*** (11.07)	0.005988*** (4.54)
Percent_preserved	0.002832 (1.05)	0.002053 (0.80)
Method_person	-1.3032*** (-13.81)	-1.644*** (-9.81)
Region_south	-0.1240*** (-3.04)	-0.1098*** (-3.03)
Mlogit	0.009816 (0.32)	-0.00293 (-0.16)
Year	-0.2184*** (-9.33)	-0.2073*** (-6.96)
-2 Log-Likelihood χ^2	1084.96 (25)	809.91 (25)
R^2 ***(OLS)***	0.6979	0.7237
N	1592	1592

*Denotes significance at $p < 0.1$; **Denotes significance at $p < 0.05$; ***Denotes $p < 0.01$

TABLE 4.
CROSS-VALIDATION: FULL MODEL VERSUS SPLIT SAMPLE RESULTS

TOWN CROSS-VALIDATION RESULTS (A)

JURISDICTION	**Mean WTP (Actual)**	**Mean WTP (Full Model Predicted)**	**Mean WTP (Split Sample Predicted)**	**Absolute Value % Error (5% Trimmed Mean) Full-Sample Model**	**Absolute Value % Error (5% Trimmed Mean) Split-Sample Model**
Woodstock, CT	$0.35	$0.38	$0.3207	83.33%	62.12%
Pomfret, CT	$0.40	$0.41	$0.4681	33.06%	54.45%
Brooklyn, CT	$0.49	$0.29	$0.2901	72.84%	78.37%
Thompson, CT	$0.23	$0.24	$0.2533	74.69%	48.46%
Smyrna, DE	$0.37	$0.37	$0.3754	76.93%	81.45%
Georgetown, DE	$0.61	$0.56	$0.5547	20.02%	24.33%
Preston, CT	$0.44	$0.40	0.4405	94.94%	89.50%
Mansfield, CT	$0.69	$0.61	0.5751	53.90%	49.38%

STATE CROSS-VALIDATION RESULTS (B)

JURISDICTION	**Mean WTP (Actual)**	**Mean WTP (Full Model Predicted)**	**Mean WTP (Split Sample Predicted)**	**Absolute Value % Error (5% Trimmed Mean) Full-Sample Model**	**Absolute Value % Error (5% Trimmed Mean) Split-Sample Model**
CT (1)	$0.012	$0.0073	$0.0088	1887.21%	70.45%
CT (2)	$0.0053	$0.0074	$0.0088	3308.00%	125.84%
DE	$0.0062	$0.0091	$0.0062	2707.98%	87.60%
ME	$0.0003	$0.0647	$0.0003	30675.72%	589.70%
GA (1)	$0.00005	$0.000083	$0.00008	33262.36%	2291.01%
GA (2)	$0.0002	-$0.0048	$0.0002	4418.79%	851.45%
OH	$0.00002	-$0.0587	$0.0002	27713.74%	2675.41%

COUNTY CROSS-VALIDATION RESULTS (C)

JURISDICTION	**Mean WTP (Actual)**	**Mean WTP (Full Model Predicted)**	**Mean WTP (Split Sample Predicted)**	**Absolute Value % Error (5% Trimmed Mean) Full-Sample Model**	**Absolute Value % Error (5% Trimmed Mean) Split-Sample Model**
Kent County, DE	$0.02	-$0.0218	-$0.0496	1478.38%	4613.75%
Sussex County, DE	$0.01	-$0.0185	$0.1416	405.08%	1561.01%
New Castle County, DE	$0.02	$0.0842	-$0.0406	598.24%	772.47%

TABLE 5.
SPLIT-SAMPLE META-REGRESSION RESULTS

Variable	**States-only Model** (t-statistic)	**Towns and Counties Model** (t-statistic)
Intercept	0.1110 (1.01)[a]	1.5277** (3.68)[a]
Acres_1000	--	0.4158*** (7.87)
Acres_1to10k	0.06169 (1.32)	--
IHSarea	--	-0.3250*** (-6.04)
Prime	0.00212*** (3.13)	--
Lvstck	0.004149*** (4.73)	0.1798* (1.96)
Forest	0.006950*** (2.96)	0.1617* (1.61)
Idle	0.005062*** (2.82)	0.1334 (1.50)
Unspec_multi	0.004882*** (3.64)	0.1780** (1.99)
Trust_pur	0.01590*** (2.68)	0.2186*** (3.73)
Trust_con	0.01519*** (6.15)	0.1114** (2.33)
S_t_pur	0.008320*** (6.17)	0.1133 (1.34)
S_t_con	0.01025*** (9.95)	0.1752** (2.34)
H_risk	0.006036*** (11.21)	0.1026*** (2.62)
No_access	-0.01017*** (-7.31)	-0.3145*** (-7.13)
Moderate_access	0.001421* (1.64)	0.3546*** (4.75)
Inc_pop	-3.08E-6 (-1.13)	-7.51E-6* (-1.78)
Urban	-0.00012 (-2.04)	--
Growth_pop	0.000114 (1.13)	0.005335*** (4.88)
Percent_preserved	-0.00137 (-1.12)	0.01217*** (4.72)
Method_person	--	-0.5125*** (-7.66)
Mlogit	0.000146 (1.59)	--
-2 Log-Likelihood χ^2	881.04 (18)	1247.02 (16)
R^2 (OLS)	0.7170	0.7589
N	644	948

*Denotes significance at p < 0.1
**Denotes significance at p < 0.05
***Denotes p <0.01