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METHODS, TRENDS AND CONTROVERSIES IN CONTEMPORARY BENEFIT TRANSFER

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Abstract. Benefit transfer uses research results from pre-existing primary research to predict welfare estimates for other sites of policy significance for which primary valuation estimates are unavailable. Despite the sizable literature and the ubiquity of benefit transfer in policy analysis, the method remains subject to controversy. There is also a divergence between transfer practices recommended by the scholarly literature and those commonly applied within policy analysis. The size, complexity and relative disorganization of the literature may represent an obstacle to the use of updated methods by practitioners. Recognizing the importance of benefit transfer for policymaking and the breadth of associated scholarly work, this paper reviews and synthesizes the benefit transfer literature. It highlights methods, trends and controversies in contemporary research, identifies issues and challenges facing benefit transfer practitioners and summarizes research contributions. Several areas of future research on benefit transfers naturally emerge.

Keywords. Benefit transfer; Environmental economics; Literature synthesis; Non-market valuation ‘

1. Introduction

Benefit transfer uses research results from pre-existing primary research to predict welfare estimates for other sites of policy significance for which primary valuation estimates are unavailable. It may be described as the ‘application of values and other information from a “study” site where data are collected to a “policy” site with little or no data’ (Rosenberger and Loomis, 2000b, p. 1097), or the ‘practice of . . . adapting value estimates from past research . . . to assess the value of a similar, but separate, change in a different resource’ (Smith *et al.*, 2002, p. 134).[1] 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 feasible option.

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For example, benefit–cost analyses required for US government rulemaking often occur under time and funding constraints as well as other requirements imposed by statutes such as the Paperwork Reduction Act;[2] these effectively prohibit the use of primary valuation studies in many instances, leaving benefit transfer as the only option for estimating non-market values (Griffiths and Wheeler, 2005; Iovanna and Griffiths, 2006).[3] In the European Union, the Water Framework Directive mandates consideration of benefits and costs for river basin management, including many large and small water bodies across multiple nations. This has led to an increasing need for benefit transfer as a cost-effective means of benefit estimation (Hanley *et al.*, 2006a, b). As a result of these and other policy considerations – and despite the challenges to valid and reliable transfers – the literature increasingly recognizes the importance of benefit transfer for applied benefit–cost analysis (Bergstrom and DeCivita, 1999; Smith *et al.*, 2002; Griffiths and Wheeler, 2005; Hanley *et al.*, 2006b; Iovanna and Griffiths, 2006; McComb *et al.*, 2006; Rolfe *et al.*, 2006; Columbo and Hanley, 2008).

Although the use of benefit transfer was common as early as the 1980s, it was not until the early 1990s that researchers began to formalize procedures and protocols (Brookshire and Neill, 1992; Freeman, 2003; Rosenberger and Loomis, 2003; Rolfe, 2006). The literature often credits a jointly sponsored 1992 Association of Environmental and Resource Economics and US EPA workshop and associated special issue of *Water Resources Research* as the inauguration of more formal treatments of benefit transfer methods (Freeman, 2003; Rosenberger and Loomis, 2003; Wilson and Hoehn, 2006). From these early developments, the literature grew rapidly, and now encompasses a large number of papers and other contributions.

While many authors express optimism regarding future prospects for development of theory and methods (e.g. Wilson and Hoehn, 2006), the literature commonly notes the need for more sophisticated techniques to address a variety of shortcomings, and also identifies a variety of important methodological questions.[4] Notwithstanding earlier attempts at methodological guidance (Desvousges *et al.*, 1998), there is still no set of consensus protocols for appropriate benefit transfer, significant methodological questions remain, and benefit transfer remains at least somewhat unreliable (Smith *et al.*, 2002; Rolfe, 2006; Navrud and Ready, 2007; Columbo and Hanley, 2008).[5] Moreover, there appears to be a divergence between methods and protocols suggested by the contemporary academic literature and methods applied by policy analysts, not in small part due to the scattering of myriad, sometimes conflicting, advances throughout the literature (Boyle and Bergstrom, 1992; Wilson and Hoehn, 2006; Columbo and Hanley, 2008).[6] Current guidance for policy applications often differs, even across documents issued by the same government agencies (e.g. guidance on the use of meta-analysis (MA) by US EPA, 2007, 2009).

Such challenges aside, there is widespread agreement that the realities of the policy process render benefit transfer largely unavoidable in modern benefit–cost analysis. The size, complexity and relative disorganization of the literature, however, represent an obstacle to the use of updated methods by practitioners. Recent discussions of method and practice are dispersed across myriad journal papers,

chapters, edited volumes or special issues of sometimes loosely related contributions (e.g. Wilson and Hoehn, 2006; Navrud and Ready, 2007) and works targeting special cases such as choice modeling or MA (e.g. Florax *et al.*, 2002a; Bergstrom and Taylor, 2006; Rolfe and Bennett, 2006). Recognizing the importance of benefit transfer for policy analysis and the imposing breadth of associated scholarly work, this review seeks to characterize the current state of the literature in a concise form. The review is meant neither to catalog the entire benefit transfer literature, nor to identify all contributions of potential relevance. Rather, it is meant to highlight the primary methods, trends and controversies in contemporary research, identify issues and challenges facing practitioners, and summarize significant and commonly cited research contributions.

2. Benefit Transfer Classifications

Earlier works often distinguished between three broad types of benefit transfer: (1) unit or fixed value transfer; (2) transfers adjusted using expert judgments and (3) function transfer (Brookshire and Neill, 1992; Desvousges *et al.*, 1998; Bergstrom and DeCivita, 1999). More recent works often eliminate 'expert judgments' as a distinct transfer method,[7] distinguishing primarily between unit value and function transfers.[8] Other categorizations, however, are common, and definitions of categories sometimes vary. For example, Smith *et al.* (2006) distinguish among unit transfer, function transfer, MA and structural preference calibration. While recognizing the many classifications that exist, here we retain the common distinction between unit value and function transfer. Unit value and function transfer may be further disaggregated into a variety of subcategories. For example, unit value transfers may involve the transfer of a simple, unadjusted value (e.g. Luken *et al.*, 1992) or a value somehow adjusted according to observable attributes of the policy site or context (e.g. income, Ready and Navrud, 2007). Functions may be drawn from various sources including individual studies and MA of data from multiple studies.

The general consensus of the literature is that function transfers typically outperform unit value transfers (Rosenberger and Stanley, 2006), although contrary or non-conclusive findings have been reported (Brouwer, 2000; Ready *et al.*, 2004; Brouwer and Bateman, 2005a), and function transfer accuracy depends on the choice of study sites (Johnston, 2007; Columbo and Hanley, 2008). At least in part for this reason, the recent literature emphasizes various types of function transfer,[9] although the literature addressing the transfer of value of statistical life (VSL) and similar health related estimates seems to be an exception.[10] This general emphasis on more sophisticated function transfer methods within the research literature does not appear to have led to a concomitant shift in predominant agency practices, an issue further discussed below.

3. Contemporary Themes and Issues

Early research in benefit transfer emphasized the establishment of models and protocols to formalize benefit transfer practices that had previously been implemented

on an *ad hoc* basis, with minimal grounding in theory or standard guidance from the literature (Boyle and Bergstrom, 1992; Brookshire and Neill, 1992; Desvousges *et al.*, 1998). Broader works such as Bergstrom and DeCivita (1999) summarized issues and the state of the practice as of that time, whereas edited volumes such as Florax *et al.* (2002a) addressed a combination of conceptual, theoretical and empirical issues related to comparative economic assessment. Simultaneously, the performance of benefit transfers was given increasing scrutiny through, for example, research that assessed the validity of benefit transfer through statistical tests of convergent validity or associated quantification of transfer errors.[11]

Beginning in the late 1990s, benefit transfer research began to emphasize function transfers, systematically evaluating applications and implications for transfer performance. Recent studies, for example, have assessed the performance of functions derived from choice experiments – a stated preference methodology designed to account for variations in environmental resources and site characteristics, as well as potential implications of these variations for willingness to pay (WTP) (Morrison and Bergland, 2006; Rolfe and Bennett, 2006).[12] The use of MA for benefit transfer has also been given increased attention during the last 10 years, although the literature provides mixed conclusions and arguments.[13] Also notable is the development of strong structural utility theoretic, or preference calibration, approaches to function transfer (Smith *et al.*, 2002, 2006; Pattanayak *et al.*, 2007), as well as transfer approaches that capitalize on Bayesian methods including updating and model averaging (Ben-Akiva, 1981; León *et al.*, 2002; Moeltner *et al.*, 2007; Leon-Gonzalez and Scarpa, 2008; Moeltner and Rosenberger, 2008).

With more than 15 years of development and assessment of methods, the literature has come to consensus over some but not all issues. For example, notwithstanding the comment of Loomis (1992) that function transfer might reduce the need for similarity across policy and study sites, there is now a fair degree of consensus that site similarity – including similarity over populations, resources, markets and other site attributes – is an important determinant of transfer validity and reliability (Loomis, 1992; Piper and Martin, 2001; Rosenberger and Loomis, 2001; Vandenberg *et al.*, 2001; Barton, 2002; Loomis and Rosenberger, 2006; Johnston, 2007; Rosenberger and Phipps, 2007; Columbo and Hanley, 2008). The literature, however, has yet to agree on a set of criteria for site similarity, so that effects of this consensus on applied practice are difficult to ascertain (Johnston, 2007; Columbo and Hanley, 2008).

Similarly, the literature is characterized by many different quantitative treatments of study site data and model results, including various classical and Bayesian statistical approaches to updating, meta-analyzing or otherwise combining data across sites, although the implications of these alternative methods for transfer reliability remain at least somewhat unclear (e.g. Rosenberger and Loomis, 2000a; León *et al.*, 2002; Smith *et al.*, 2002; Bateman and Jones, 2003; Moeltner *et al.*, 2007; Leon-Gonzalez and Scarpa, 2008; Moeltner and Rosenberger, 2008; Nelson and Kennedy, 2009). Other areas of transfer methodology remain similarly subject to disagreement and there are many areas of practice for which researchers express a general lack of satisfaction (Wilson and Hoehn, 2006) or for which assessments

have shown a lack of reliable performance (Smith *et al.*, 2002; Navrud and Ready, 2007; Columbo and Hanley, 2008). Primary themes in benefit transfer research and dialogue relate to issues for which consensus has not yet been reached regarding best practice or means to ameliorate well-known shortcomings in methods and performance.

3.1 *Estimation and Transfer of Benefit Functions*

Benefit functions may be derived from single studies or methods that combine information from two or more studies.[14] Functions are most often drawn from within a single country, but may also be estimated from data that span multiple countries (Ready and Navrud, 2006; Brander *et al.*, 2007; Lindhjem and Navrud, 2008); see additional discussion of international transfer below. As a broad generalization, the literature seems to favor functions drawn from studies or transfer methods that allow greater flexibility to adjust for variations in environmental resource and site characteristics, as well as potential implications of these variations for WTP (Morrison and Bergland, 2006).[15]

The quality of function-based transfer depends on the quality of the primary research upon which it is based (Brookshire and Neill, 1992; Desvousges *et al.*, 1998; Brouwer, 2000; Rosenberger and Stanley, 2006). Beyond this general observation, there appears to be little consensus on the comparative performance and validity of different types of function transfer. Some comparisons of performance across different types of function transfer have been conducted (e.g. single site versus MA, domestic versus international, Bayesian versus classical estimation) with variable results (e.g. Smith and Huang, 1995; Engel, 2002; Moeltner *et al.*, 2007; Shrestha *et al.*, 2007; Lindhjem and Navrud, 2008). As discussed below for MA and preference calibration, however, there is still a lack of consensus regarding the most generally appropriate means to generate functions when multiple alternatives are available. Moreover, comparisons show wide variation in transfer errors for similar types of functions (Brouwer and Spaninks, 1999; Rosenberger and Stanley, 2006). As a result, despite arguments for the advantages of specific types of function transfer, empirical evidence fails to provide unequivocal support for the superiority of any specific type.

3.2 *Value Surfaces and Meta-analysis*

In a commonly quoted characterization, Glass (1976, p. 3) describes MA as 'the statistical analysis of a large collection of results for individual studies for the purposes of integrating the findings. It provides a rigorous alternative to the casual, narrative discussion of research studies which is commonly used to make some sense of the rapidly expanding research literature.' Nelson and Kennedy (2009) identify 130 MAs in environmental economics, of which half have been conducted since 2003. Within economic inquiry, MA can be used for a variety of purposes. In benefit transfer contexts, it is most often used to identify and test systematic influences of study, economic and resource attributes on WTP, to characterize results of the literature addressing certain classes of

non-market values and to generate reduced form functions for direct transfer applications. All of these are grounded in the ability of MA to characterize a value surface reflecting the measurement of multi-dimensional patterns in estimated WTP variation across empirical studies. Most benefit transfer examples involve the use of meta-regression, in which the dependent variable in a Bayesian or classical regression model is a summary statistic drawn from comparable primary studies (often a WTP estimate for a specified type of resource change), and independent moderator variables characterize resource, policy, context and population attributes hypothesized to explain observed variation in the dependent variable across primary study observations (Nelson and Kennedy, 2009).

Many authors note the potential of meta-regression models to provide more robust, reduced error benefit transfers compared to alternative transfer methods.[16] Empirical evidence – albeit limited – suggests that this may be true in some instances (Rosenberger and Stanley, 2006). The use of MA for estimation of reduced form functions, however, remains controversial. A number of works advise caution in the use of MA for welfare estimation, often based on case study evidence of poor empirical performance, inadequate methods, insufficient commensurability across included studies and the difficulty of applying MA to non-experimental data (e.g. Poe *et al.*, 2001; Florax *et al.*, 2002b; Smith and Pattanayak, 2002; US EPA, 2007; Nelson and Kennedy, 2009). Still others emphasize the lack of structural theoretical foundations for many meta-regression models (Smith and Pattanayak, 2002; Bergstrom and Taylor, 2006). A middle-ground is taken by Nelson and Kennedy (2009), who attempt to specify a series of best practice guidelines for MA used to address policy problems, but at the same time suggest that many MAs in the literature fail to meet these standards. A similar position is taken by Desvousges *et al*. (1998, p. 36): '[i]t is important to put such criticisms of MA in the appropriate context . . . . While there are many problems in using MA, the alternatives may be subject to even greater concerns.'

Despite such disagreements there have been many advances and relevant findings.[17] In addition, there have been increasing efforts to develop MAs for the purpose of agency benefit transfer and to better define units of measurement (i.e. of valued goods) in ways better linked to models used by agencies to predict policy-related changes (Rosenberger and Loomis, 2001, 2003; Johnston *et al.*, 2003, 2005, 2006b; van Houtven *et al.*, 2007; Santos, 2007; Johnston and Besedin, 2009).

3.3 *Structural Benefit Transfer*

Benefit transfers, in general, lack a micro-level theoretical foundation upon which to 'evaluate the multiple judgments associated with transfers' (Smith *et al.*, 2002, p. 134).[18] Such limitations apply to unit and single-study function transfers, as well as to MA functions (Smith and Pattanayak, 2002). With regard to the latter, Bergstrom and Taylor (2006) distinguish among strong structural utility theoretic models, weak structural utility theoretic models, and non-structural utility theoretic models, with virtually all MAs falling into the latter two categories, and only the former two categories judged to be suitable for benefit transfer.

Smith *et al.* (2002) propose an alternative which they name 'structural benefit transfer' or 'preference calibration'. Structural benefit transfer is distinguished by a formal basis in an explicit, structural utility function. As characterized by Smith *et al.* (2006), structural benefit transfer requires the analyst to specify a preference or utility function able to describe an individual's choices over a set of market and non-market goods, presuming standard budget-constrained utility maximization. One then derives analytical expressions that determine a relationship between each available benefit measure and the assumed utility function, inasmuch as possible guided by economic theory. Expressions also should 'assure the variables assumed to enter the preference function are consistently measured across each study and linked to preference parameters' (Smith *et al.*, 2002, p. 136). Finally, empirical methods are used to calibrate parameters to the specified utility-theoretic structure. Parallel approaches have been suggested for MA by Smith and Pattanayak (2002).

Proponents of preference calibration argue that such approaches provide advantages over other transfer methods; these advantages include a model that imposes theoretical consistency on the use of prior information. The method, however, is not without limitations, not the least of which is a requirement of strong *a priori* assumptions regarding the underlying structural model, although all transfers involve implicit or explicit assumptions of some type (Smith *et al.*, 2006; Rosenberger and Phipps, 2007). The preference calibration method also is more complex than most alternative transfer methods, and the literature has yet to demonstrate that this increased complexity leads to empirical improvements in transfer performance. The complexity of the method and perception that it requires strong assumptions has limited its adoption, with all published applications (to the knowledge of the authors) conducted by the researchers who developed the original method (e.g. Smith and Pattanayak, 2002; Smith *et al.*, 2002, 2006; Pattanayak *et al.*, 2007).

While preference calibration applications are limited, there is broader agreement on the potential benefits of utility theoretic structure within transfers (e.g. McConnell, 1992; Boyle *et al.*, 1994; Engel, 2002; Bergstrom and Taylor, 2006). What is less clear is the extent to which researchers are willing to accept the perceived limitations of preference calibration or similar approaches in exchange for this structure, or whether weaker utility linkages will be perceived as adequate (Bergstrom and Taylor, 2006). For example, commenting on structural transfer methods, Navrud and Ready (2007, p. 288) state that '[s]imple approaches should not be cast aside until we are confident that more complex approaches do perform better'. Future research has yet to determine the potential impacts of greater utility structure on empirical transfer validity and reliability, and whether structural transfer will experience broader acceptance as analysts become more familiar with such methods.

3.4 *Testing Validity: Methods and Results*

Benefit transfers are subject to a variety of potential errors, many of which are directly or indirectly related to the issues discussed throughout this paper; for example commodity inconsistency (Desvousges *et al.*, 1998; Bergstrom and

DeCivita, 1999; Smith *et al.*, 2002; Rosenberger and Stanley, 2006) and lack of site similarity (Johnston, 2007; Rosenberger and Phipps, 2007; Columbo and Hanley, 2008). These errors are often grouped into two general categories. Primary study *measurement errors* reflect potential divergences between a true underlying value and a primary study estimate – these are errors associated with the original study from which transfer estimates are derived (Bockstael and Strand, 1987; McConnell, 1992; Rosenberger and Stanley, 2006). *Generalization* or *transfer errors*, in contrast, are errors related to the transfer process itself (Brookshire and Neill, 1992; Rosenberger and Stanley, 2006). Generalization errors are related to such factors as the correspondence between sites and populations, the commensurability of non-market goods and policy contexts, and the benefit transfer methods applied (Rosenberger and Phipps, 2007).

Many studies express concern regarding the accuracy and validity of benefit transfer, and there have been numerous attempts to assess statistical validity and the magnitude of transfer error in various contexts (Bergstrom and DeCivita, 1999; Brouwer and Spaninks, 1999; Rosenberger and Loomis, 2003; Morrison and Bergland, 2006; Rosenberger and Stanley, 2006). Results of these tests have been mixed, leading Smith *et al.* (2002, p. 134) to argue that 'conventional approaches are very unreliable . . .'. Other sources emphasize that the acceptable level of transfer accuracy is context dependent – while the validity of transfers is a purely statistical issue unrelated to the policy context or needs,[19] required accuracy or reliability depends on the level of error deemed acceptable in a given policy context (Ben-Akiva, 1981; Desvousges *et al.*, 1998; Bergstrom and DeCivita, 1999; Kristofersson and Navrud, 2005; Columbo and Hanley, 2008; Stapler and Johnston, 2009). Given this context dependence, the literature has been hesitant to quantify minimum acceptable reliability thresholds. However, it is suggested that an acceptable level of error is a function of the precision necessary for different types of decisions (Navrud and Pruckner, 1997). For example, higher degrees of precision and consequently lower transfer errors are needed as one moves from broad benefit–cost analyses for information gathering or screening of projects and policies to calculation of compensatory amounts in negotiated settlements and litigation.

As noted above, out-of-sample predictive performance, or convergent validity testing, is the typical focus of validity and error assessments (Rosenberger and Stanley, 2006). In these tests, transfer estimates are compared to a primary study estimate for the site in question. A smaller difference between the calibrated transfer estimate and a primary estimate specific to the transfer site, denoted transfer or generalization error, suggests increased transfer accuracy. This is sometimes denoted reliability testing (Lindhjem and Navrud, 2008).[20] Findings of such assessments vary, with average within study errors ranging from a few percentage points to 500% or more (Rosenberger and Stanley, 2006). Notwithstanding this wide variation, results from the literature suggest numerous patterns. For example, errors are generally found to be smaller in cases where sites and populations are more similar (Rosenberger and Phipps, 2007).[21]

Drawing from estimated generalization or transfer errors, transfer validity is generally assessed using hypothesis tests in which welfare estimates are

presumed equal unless statistical tests reject a null hypothesis of estimate equality (Kristofersson and Navrud, 2005; Johnston and Duke, 2008). Common assessments test the equality of estimated parameters (e.g. demand or utility function coefficients), implicit prices, and/or welfare estimates (e.g. consumer surplus, compensating surplus etc.).[22] Results often differ depending on the measure considered (Johnston, 2007). The limitations of such approaches are well known. For example, as noted by Rosenberger and Stanley (2006, p. 374), 'even if the process of benefit transfer were without error, the transferred value would be expected to differ from the actual value by the square root of the sum of the estimation variances of [the] two sites'. The inability of standard hypothesis tests to account for the varying accuracy demands of different contexts is also well established (Ben-Akiva, 1981; Lerman, 1981), as is the counterintuitive result that less efficient statistical estimates (i.e. larger standard errors) are more likely to be found suitable for transfer (Kristofersson and Navrud, 2005). Nonetheless, standard hypothesis tests – assessing the null hypothesis that transfer error is equal to zero – remain the norm in the benefit transfer literature (Lindhjem and Navrud, 2008). Alternatives, however, have been proposed; these alternative testing methods may provide a more appropriate and revealing perspective on transfer performance (Ben-Akiva, 1981; Lerman, 1981; Desvousges *et al.*, 1998; Spash and Vatn, 2006; Lindhjem and Navrud, 2008).

For example, a small but growing literature discusses the use of equivalence testing within benefit transfer (Muthke and Holm-Mueller, 2004; Kristofersson and Navrud, 2005; Hanley *et al.*, 2006a; Johnston, 2007; Johnston and Duke, 2008). Compared to traditional hypothesis tests, equivalence testing reverses traditional null and alternative hypotheses and the burden of proof. That is, welfare estimates are assumed different unless hypothesis tests can demonstrate, with a chosen probability level, that the difference is smaller than a specified tolerance limit within which values are considered equivalent. For benefit transfer, this tolerance limit represents the maximum transfer error permitted while maintaining the equivalence of the original study result and benefit transfer estimate. Recent advances include variants of the traditional equivalence test based on the difference between independent empirical distributions that permit valid inference for non-normal distributions (Johnston and Duke, 2008).

Other approaches for evaluating validity avoid hypothesis testing altogether and emphasize either value surfaces or the sensitivity of results to analyst assumptions. For example, one may compare two or more transfer estimates to assess robustness with respect to analyst practices (Desvousges *et al.*, 1998) or assess the correspondence of value surfaces with theoretical expectations (Bergstrom and DeCivita, 1999). Often, such approaches are presented as complements to validity testing based on the convergence of welfare estimates.

3.5 *Commodity Consistency and the Architecture of Non-market Values*

The literature expresses general agreement that commodity consistency is a prerequisite for valid transfer (Boyle and Bergstrom, 1992; Smith and Pattanayak,

2002; Smith *et al.*, 2002; Johnston *et al.*, 2005; Loomis and Rosenberger, 2006). This relates to more general concepts concerning the architecture of non-market values (Johnston and Thomassin, 2009).[23] That is, appropriate transfers require an understanding of the underlying quantities or qualities (i.e. definitions of non-market goods) at affected sites both in primary studies from which values are estimated and in transfer sites for which value estimates are needed. Even studies of seemingly similar non-market goods may estimate values for differing underlying quantities or qualities.[24]

Even given consistently defined commodities, value estimates may diverge when different valuation methods are used, a common empirical pattern that is often consistent with theoretical expectations (Smith and Pattanayak, 2002; Smith *et al.*, 2002; Freeman, 2003).[25] Moreover, as discussed by Brouwer (2000) and Johnston and Duke (2008), households' WTP for seemingly similar physical or ecological changes may be sensitive to such factors as the underlying policy process through which change is realized, attributes of local historical or cultural context, whether households interpret policy choices in citizen versus consumer roles, and other factors that further add to the complexity of producing generally applicable value models. Many of these may be difficult to quantify, further contributing to the challenge facing transfer practitioners.

Although it is sometimes possible to reconcile commodity definitions across studies, reconciliation that promotes sufficient uniformity is not always feasible (Smith *et al.*, 2002; van Houtven *et al.*, 2007), and analysts are often 'delinquent' in such areas (Nelson and Kennedy, 2009, p. 346). The task is made more difficult 'as [the] complexity of changes in environmental quality and natural resources increase[s]' (Navrud and Ready, 2007, p. 3). McConnell (1992), among others, emphasizes the role of researcher judgment in benefit transfer, particularly as related to the comparison of results across different valuation contexts and methodologies. In many cases, however, assumptions required to reconcile commodity definitions across sites are not well specified.

Concerns related to commodity consistency are particularly apparent for transfers involving MA. All MAs in the valuation literature make explicit or implicit assumptions regarding the commensurability or reconcilability of welfare measures from numerous valuation contexts (Engel, 2002; Smith and Pattanayak, 2002; Johnston *et al.*, 2005; Loomis and Rosenberger, 2006; Nelson and Kennedy, 2009). While appropriately specified MAs may be able to account for systematic patterns relating theoretically distinct welfare measures for otherwise similar commodities, MA cannot by itself solve challenges related to commensurability. As stated by Bergstrom and Taylor (2006, p. 354):

> To account for commodity inconsistency related to reference and target level effects, range differences, or differences in range and spatial and temporal scales, either adjustments need to be made in the dependent variable, or the source of commodity inconsistency needs to be controlled for on the right-hand side of the [meta-analysis regression] equation . . . Accounting for commodity inconsistency by adjusting the dependent variable prior to estimation may be problematic if it fundamentally changes the nature of what people valued (or perceived they

valued). However, accounting for commodity inconsistency by adding variables to the right-hand side of the . . . equation may also be problematic because it introduces restrictions into the model that may or may not be plausible.

Nelson and Kennedy (2009) also emphasize difficulties in MA related to a lack of comparable data across studies and heterogeneity across evaluated activities and sites. However, consensus on the conceptual architecture through which the quantity of environmental changes or non-market goods may be defined, measured and contrasted is still lacking. Without consensus, decisions made during benefit transfer research or policy applications to reconcile non-market commodity definitions will likely continue to be perceived as *ad hoc*.

3.6 *The Effect and Treatment of Study Methodology*

Analysts conducting primary non-market valuation may choose among several methods (Freeman, 2003). Choices facing researchers involve such issues as general modeling approach (e.g. stated versus revealed preference), empirical estimation procedures, survey design (e.g. question framing, information provided), survey implementation (e.g. mail, in-person, telephone), the extent of the market, treatment of observations (e.g. protest bids, outliers) and others (Rosenberger and Johnston, 2009). Such choices often result in systematic effects on welfare estimates. In most site-to-site benefit transfers, effects of valuation methodology are embedded in transfer estimates and cannot be identified. Hence, even when methodological effects are present they are typically invisible to researchers. These effects can become visible, however, in meta-regression models. Estimation of these systematic effects has been one of the goals of recent meta-regression analysis in the environmental economics literature.[26]

In some instances, theory indicates that methodological variations should influence welfare estimates (Smith and Pattanayak, 2002; Johnston *et al.*, 2003, 2006b; Stapler and Johnston, 2009), a fact sometimes overlooked in the literature. For example, theory suggests that welfare estimates for otherwise identical resource improvements should not be convergent for most revealed and stated preference analyses – these two methodological categories generally provide distinct welfare measures (Smith *et al.*, 2002; Freeman, 2003; Johnston *et al.*, 2003).[27] Recent evidence also suggests that market structure, institutions and environment can influence economic behavior in theoretically expected and predictable ways (Johnston and Duke, 2009a; Rosenberger and Johnston, 2009). The experimental economics literature illustrates that different auction or preference elicitation mechanisms provide different economic incentives and elicit different behaviors (Poe *et al.*, 2002; Braga and Starmer, 2005), and that similar behavioral anomalies manifest in both actual and hypothetical markets (Bateman *et al.*, 2008). In addition, there is longstanding evidence that the quantity and presentation of information influences economic behavior (Bergstrom *et al.*, 1990; Hoehn and Randall, 2002).

While the potential influence of study methodology on welfare estimates is clear, there is less consensus on whether methodological impacts on non-market WTP reflect pervasive biases or, alternatively, theoretical and empirical patterns

that are broadly consistent with utility theoretic welfare estimation (Rosenberger and Johnston, 2009). This lack of consensus aside, the primary concern for benefit transfer is twofold. First, unless analysts apply MA or other mechanisms that reveal methodological effects on welfare estimates, these effects will have an unknown but possibly systematic influence on transfer validity and error. Second, even when methodological effects are estimated, there remains a question regarding the appropriate treatment of these effects when using meta-regression models to predict welfare estimates (Johnston *et al.*, 2006a; Rosenberger and Johnston, 2009; Stapler and Johnston, 2009). The use of an estimated meta-regression equation for benefit transfer requires that the analyst assign values (i.e. choose variable levels) for all independent variables, so that a transferable WTP prediction can be obtained (Stapler and Johnston, 2009). Neither theory nor attributes of policy sites, however, dictate the values for methodological variables that should be used in the parameterized function to generate WTP estimates; there is no way to observe the 'correct' methodology for any given policy site. Meta-analysis function transfers typically forecast WTP assuming mean values for methodological covariates[28] or through the use of other *ad hoc* approaches (Johnston *et al.*, 2006a; Moeltner *et al.*, 2007; Stapler and Johnston, 2009).

Just as primary researchers must make choices regarding methods to be used, including experimental and survey design, transfer analysts must make choices regarding ways to address systematic methodology effects. Theory can only provide limited assistance for these choices. Each approach has pros and cons, and thus far the literature provides limited guidance regarding approaches to methodology effects in a benefit transfer setting.

3.7 *Selection Effects and Quality Control in Primary Studies*

When one selects studies from the literature for benefit transfer, there are implicit assumptions that (1) the underlying body of valuation literature is a random, unbiased sample of the population of empirical estimates, and (2) empirical estimates provide an unbiased representation of true, underlying resource values. If these assumptions are unfounded and the literature does not provide an unbiased reflection of resource values, the result will be systematic transfer biases. Such concerns are most often noted for the case of MA (Rosenberger and Johnston, 2009), but apply to all types of transfer. Benefit transfers can only be as good as the sample of data from which they are derived, or to the extent that any biases may be corrected during transfer. While past works provide some discussion of such issues (Smith and Pattanayak, 2002), implications for benefit transfer are not widely recognized. As a result, MA, reporting of associated results and benefit transfers are often conducted without explicit recognition of the importance of the underlying sample of primary studies. Unlike other challenges that relate to *generalization errors* in the transfer of an estimated value between sites, selection effects reflect a type of *measurement error*, or the ability of the literature as a whole to provide an unbiased characterization of true value distributions. Like selection effects in any area of inquiry, consequences for transfer validity and reliability will

vary according to empirical patterns, but could be substantial when these effects are pervasive or severe.

Discussions of selection effects are sparse and scattered throughout the literature.[29] Rosenberger and Johnston (2009) provide the only comprehensive discussion of selection effects in benefit transfer, and this analysis focuses primarily on MA. They identify four potential sources of selection bias in any given body of literature, including research priority selection, methodology selection, publication selection and (metadata) sample selection. By not accounting for selection biases in the literature, these biases may carry over into empirical benefit transfers – including those conducted using MA.

Research priority selection may be driven by sociopolitical circumstances such as the societal awareness and perceived importance of a particular resource, or the extent to which agencies are willing and able to fund research in a particular area (Hoehn, 2006; Rosenberger and Johnston, 2009). In such cases, analyses may tend to target resources with higher marginal or total values, all else held constant. Methodology selection, in turn, affects WTP estimates and further complicates benefit transfers when methodological characteristics are significant determinants of the variation in WTP, as noted above. Publication selection may bias a research literature, and there are signs of such bias in many areas of inquiry (Florax, 2002; Stanley, 2005, 2008; Rosenberger and Stanley, 2006). Due to journal, reviewer, and researcher publishing criteria, results of entire studies, standard data sets and models, and specific information on study sites and sample populations may be suppressed. Even once a study is present in the literature there is no guarantee that it will be selected by researchers implementing MA or benefit transfer. Just as sample selection is known to bias estimates of value if not corrected in primary data models (Garrod and Willis, 1999; Bateman *et al.*, 2002), it is also a relevant concern for meta-regression models (Bergstrom and Taylor, 2006; Moeltner and Rosenberger, 2008; Rosenberger and Johnston, 2009). Defining policy-relevant resources and identifying relevant studies to be included in the metadata can affect the estimated meta-valuation function and predicted values that arise.

Implementation of valid benefit transfer requires that researchers not only identify patterns associated with the above-noted selection effects, but also take appropriate actions to ameliorate these effects (Rosenberger and Johnston, 2009). In some cases, theory provides clear guidance for appropriate assumptions and treatments. In other cases, neither economic theory nor the literature provides unequivocal guidance, leading to a situation in which *ad hoc* researcher decisions may have substantial influence on benefit transfer results. In such cases, it is critical to identify the sensitivity of transfer estimates to researcher decisions, ensuring that this information is transparent to those applying benefit transfer estimates. Selection effects is an area in which future research is required.

3.8 *Spatial Patterns and the Extent of the Market*

All benefit–cost analyses require assumptions regarding the extent of the market or spatial aspects of resource values. Similarly, the application of benefit transfer

often requires the analyst to make assumptions, or somehow model, the relationship between geographic space and transferred values or functions (Desvousges *et al.*, 1998). Bateman *et al.* (2006), Loomis (1996, 2000) and Smith (1993), among others, argue that assumptions regarding the spatial distribution of values can dominate the outcome of benefit–cost analyses, potentially overwhelming other issues often given much greater attention in the literature.

Studies of spatial patterns in WTP are numerous and can address such issues as continuous distance decay in WTP and the distribution of a given quantity of environmental improvement (e.g. land preservation) over jurisdictions of different dimensions.[30] However, unlike primary valuation – in which the extent of the market may at least in theory be estimated using empirical data – benefit transfer applications often provide little policy site information to assist analysts in quantifying market extent or spatial aspects. In some cases, physical linkages will define the extent of the market (Smith, 1992; Desvousges *et al.*, 1998).[31] In many other cases, including all of those involving non-use values, the extent of the market cannot be determined by easily observable parameters, thus requiring analyst judgment (Smith, 1992, 1993; Desvousges *et al.*, 1998).

Analysts must address two closely related questions when determining the extent of the market for any given benefit transfer. First, what is the total extent of the economic market (what population is assumed to have a value for the environmental change in question)? Second, what are expected patterns of preferences or value over the spatial extent of the market (does WTP change systematically over space from a location at which an environmental change occurs)? Within typical benefit transfer contexts, both questions must be answered using insights and results provided by studies conducted elsewhere. Answers, however, can be elusive, as research suggests that spatial patterns in non-market values can be sensitive to valuation context and resources considered, and primary studies often provide minimal information on such patterns (Loomis and Rosenberger, 2006).

Even in the unusual instances in which researchers can accurately approximate the extent of the market for a given environmental change, benefit transfer still requires either implicit or explicit assumptions regarding distance decay in welfare within the presumed market. While the concepts of distance decay and market extent are closely linked, they are not identical. For example, it is possible for certain public goods to have a constant average impact on residents' utility within a given geographical market that does not decline – or changes by only a trivial amount – over distance. However, while not all environmental changes will be characterized by a continuous decay in associated non-market value over space, numerous studies demonstrate distance decay of total and use WTP associated with a variety of natural resource changes, suggesting that such patterns can represent an important consideration (Hanley *et al.*, 2003; Bateman *et al.*, 2006; Campbell *et al.*, 2008).

Combining evidence from the literature, it is clear that spatial patterns in policy impacts and public preferences are critical aspects of benefit aggregation and transfer. However, while these patterns are well established, the current literature is too sparse to provide a broadly applicable library of transferable information on

spatial pattern. As a result, most transfers rely on *ad hoc* mechanisms to specify these patterns for benefit approximation or aggregation (Smith, 1993; Loomis, 1996, 2000; Bateman *et al.*, 2006). Recent work addresses various options for more formally incorporating spatial patterns within benefit transfer, including spatial microsimulation (Hynes *et al.*, 2008), the use of choice experiments to characterize spatial patterns in WTP (Campbell *et al.*, 2008) and spatial data supplemented meta-regression (Johnston and Duke, 2009b), among others. This and related work aside, the incorporation of spatial pattern is one of the less well-developed areas of benefit transfer methodology. Without future research addressing spatial patterns in policy and welfare impacts, it is likely that transfers will continue to rely on perfunctory methods.

3.9 *Temporal Trends in Non-market Values*

Benefit transfers involve a transfer not only across geographical space but also across time (Eiswerth and Shaw, 1997; Brouwer, 2006; Zandersen *et al.*, 2007). It is often presumed that temporal effects in these and similar cases may be dealt with through an appropriate specification of discount rates and currency conversions, for example to account for inflation (Pattanayak *et al.*, 2002; Ready and Navrud, 2006). Supporting such presumptions, several studies have assessed test–retest reliability, finding that absent major events or market changes that might be expected to alter preferences or values (cf. Brouwer, 2006), non-market values are temporally robust over short time spans (Loomis, 1989; Downing and Ozuna, 1996; McConnell *et al.*, 1998). The validity of transfers over longer time horizons, however, is less certain. Zandersen *et al.* (2007), for example, show that preferences for forest recreation change significantly over a 20-year time horizon, but that updating older models with present recreation demand data can substantially reduce associated transfer errors. In addition, individual studies and MAs often show time trends in non-market values (Brouwer and Bateman, 2005b; Rosenberger and Johnston, 2009).

Overall, the literature provides only modest guidance regarding the systematic treatment of potential preference, market and methodological changes over time within benefit transfers. While the potential importance of temporal patterns have been recognized (e.g. Krupnick, 1993; Downing and Ozuna, 1996; Eiswerth and Shaw, 1997; Pattanayak *et al.*, 2002; Rozan, 2004; Zandersen *et al.*, 2007), there have been relatively few systematic assessments of such issues within a benefit transfer context (Brouwer, 2006). Moreover, improvements in valuation methodologies occur over time, sometimes complicating direct convergent validity comparisons of studies conducted in different time periods (Rosenberger and Johnston, 2009).

3.10 *International Benefit Transfer*

In some instances, benefit transfers are conducted between countries or include data drawn from multiple countries (Ready *et al.*, 2004; Brouwer and Bateman, 2005a; Lindhjem and Navrud, 2008). International benefit transfer may be of particular

interest in nations or regions for which a relatively small number of original studies are available, and benefit transfer hence requires the supplementation or substitution of in-country data with out-of-country information (Thomassin and Johnston, 2008). However, there are numerous challenges to international benefit transfer in addition to those common in domestic transfers.

When conducting transfers of any type across national borders one must account for a variety of complications not encountered in intra-country transfer (Pattanayak *et al.*, 2002; Ready and Navrud, 2006). For example, it may be necessary to adjust for patterns in WTP related to such factors as (1) currency conversion, (2) user attributes, (3) wealth and income measures, (4) cultural differences, (5) extent of the market and (6) value adjustments (Ready and Navrud, 2006; Thomassin and Johnston, 2008). Compared to domestic transfers, international transfers may face additional challenges related to study heterogeneity, data poolability, value surface homogeneity and divergent sample selection considerations (Lindhjem and Navrud, 2008; Rosenberger and Johnston, 2009). For example, as suggested by Ready and Navrud (2006) for benefit transfer in general and by Lindhjem and Navrud (2008) for meta-analytic transfer, the heterogeneity of study attributes across countries may be greater, *ceteris paribus*, than that of attributes within countries. In some cases, MA provides a partial means to ameliorate or at least make explicit many of these issues by elucidating differences in value surfaces across countries or variations in the impact of user attributes on WTP (Thomassin and Johnston, 2008). These and related issues, however, have yet to be addressed in a comprehensive manner.

While the literature includes a variety of transfers and MAs that include or compare data from multiple nations (e.g. Johnston *et al.*, 2001; Shrestha and Loomis, 2001; Muthke and Holm-Mueller, 2004; Ready *et al.*, 2004; Rozan, 2004; Brouwer and Bateman, 2005a; Brander *et al.*, 2007), there are fewer analyses that attempt a more systematic assessment of issues and complexities involved with the use of international MA for benefit transfer (e.g. Brouwer and Bateman, 2005a; Lindhjem and Navrud, 2008; Thomassin and Johnston, 2008). Results thus far provide a mixed message for those seeking to conduct international transfers; while some transfers have been shown to pass convergent validity tests (Shrestha and Loomis, 2003), other assessments have shown significant differences in value surfaces (e.g. Muthke and Holm-Mueller, 2004; Ready *et al.*, 2004; Rozan, 2004; Brouwer and Bateman, 2005a; Lindhjem and Navrud, 2008; Thomassin and Johnston, 2008). With the exception of a few works, the literature offers relatively modest guidance regarding the challenges involved in such analyses. This is another area in which research is required.

3.11 *Scholarly Research and Applied Practice*

Although the literature now emphasizes the use of function transfers and other sophisticated methods as a means to reduce transfer errors and improve transfer validity, this appears to have had only limited impact on agency practice. Prior to the early 1990s most transfers were empirical and involved the use of point estimates, measures of central tendency or administratively approved values (Rosenberger

and Loomis, 2003). This is not surprising given the lack of broad familiarity with function transfer methods prior to Loomis (1992). Despite arguments that more sophisticated techniques are needed to improve benefit transfer (Bergstrom and DeCivita, 1999; Smith *et al.*, 2002; Spash and Vatn, 2006), agency benefit–cost analyses are still dominated by unit value transfers (Iovanna and Griffiths, 2006). In some instances, more sophisticated approaches have been proposed (e.g. the use of an MA to estimate ecological benefits for the US EPA (2004) 316(b) Phase II Rule), but have ultimately been excised from final assessments (Johnston *et al.*, 2005; Iovanna and Griffiths, 2006).

Although various national and international agency publications in the USA, European Union and elsewhere provide guidance for benefit transfer applications (e.g. Commonwealth of Australia, 2002; UK Environment Agency, 2004; Pearce *et al.*, 2006; US EPA, 2007, 2009), a general divergence between the academic literature and agency practice is evident. As noted by Wilson and Hoehn (2006, p. 336), many 'innovative ideas and important breakthroughs . . . remain scattered and disconnected throughout the peer-reviewed literature'. Moreover, there is often a lack of incentive for academic economists to conduct and publish empirical research in a manner conducive to benefit transfer applications or that do not otherwise exceed some threshold of methodological innovation (Rosenberger and Johnston, 2009). As a result, many of the advances of the literature are too costly (in terms of complexity or data needs) to implement in agency analyses (McComb *et al.*, 2006; Wilson and Hoehn, 2006). This, combined with the 'absence of a systematic protocol for benefit transfer analysis' (Smith, 1992, p. 690), has led many external observers to question the validity of transfers as applied by government agencies.

Among the areas in which opinions of academic researchers and non-academic practitioners often diverge is the role of non-market valuation databases. These databases summarize results and details of valuation studies (Morrison, 2001; McComb *et al.*, 2006), and often include search features that enable users to identify studies with particular characteristics. For example, the Environmental Valuation Reference Inventory (EVRI, http://www.evri.ca/) is an internet database that contains summaries of empirical studies of the economic value of environmental costs and benefits and human health effects. Similar but smaller databases include ENVALUE (http://www.environment.nsw.gov.au/envalue/), developed by the New South Wales Environment Protection Authority. Academics tend to view these and other databases as a useful starting point for research or policy analysis and as an important source of information regarding the valuation literature, but treat with skepticism transfers that rely solely on database information (Morrison, 2001; Johnston and Thomassin, 2009). Recent surveys, in contrast, indicate that a majority of database users support the addition of 'reduced form equations or spreadsheet tools for direct use in benefit transfer', suggesting a divergence of opinion regarding the appropriate role of these databases (Johnston and Thomassin, 2009).

Advances and improvements in common benefit transfer research and practice may be made in many areas; much of this burden rests on academic researchers. For example, despite great efforts among academic economists to improve valuation and benefit transfer methodologies, and a substantial methodological research

literature, benefit transfer analysts nonetheless face a 'lack of adequate [empirical] studies for benefit transfer' (Loomis and Rosenberger, 2006, p. 344). Similarly, van Houtven *et al.* (2007, p. 225) note 'a continued need for . . . valuation research that can be used to address the requirements of national and regional-scale benefit assessments'. Moreover, few assessments address benefit transfer within the context of actual policy implementation (Moeltner and Woodward, 2009). Simply put, the literature provides insufficient empirical foundation for transfer applications.

Limitations of existing academic research for benefit transfer applications include an emphasis on methodological 'twists' and advances that often precludes direct policy use, inadequate reporting of results and data, insufficient realism of empirical applications or tenuous links to measurable policy outcomes and a dearth of contributions that focus on the provision of high quality, well-documented empirical estimates of non-market values (Smith and Pattanayak, 2002; Loomis and Rosenberger, 2006; McComb *et al.*, 2006; Wilson and Hoehn, 2006; van Houtven *et al.*, 2007; Moeltner and Woodward, 2009; Rosenberger and Johnston, 2009). These limitations are often a direct result of incentives facing academics. For example, as stated by McComb *et al.* (2006, p. 471), '[p]ressure from publications to create novel methods or formulations has resulted in an abundance of studies that are distant from the day-to-day needs of policy makers . . .'.

Similarly, the literature is characterized by large numbers of studies in some areas (e.g. values for big game hunting) and many fewer in others (e.g. values for environmentally sensitive, watchable wildlife) (Loomis and Rosenberger, 2006); this disparity is often related to priorities among agencies that fund primary research (Rosenberger and Johnston, 2009). Hence, despite the existence of thousands of non-market valuation studies, analysts often struggle to find research suitable for particular transfer applications (McComb *et al.*, 2006). Although such limitations in the research literature and associated academic incentives are well known, solutions have been elusive.

4. Conclusions

Benefit transfer is one of the most commonly used, but also most controversial, components of benefit–cost analysis. It is an area in which researchers are making significant advances, but also one in which methods applied in government policy analysis often fall short of those proposed in the research literature. Many of the primary challenges relate to a lack of accessible, unbiased information. Despite a substantial research literature, there is a lack of studies providing high quality, policy relevant, replicable, empirical estimates of non-market values for many environmental commodities. Instead, the published literature is dominated by studies providing methodological advances, often at the expense of useful empirical estimates. Similarly, the literature often fails to provide sufficient information on study attributes and data to promote defensible transfer (Loomis and Rosenberger, 2006). Also lacking are easily accessible data and criteria to help policy analysts assess the quality and appropriateness of primary studies for benefit transfer applications (Morrison, 2001). The valuation literature has also been shown to be

subject to a wide range of selection biases that, if left unrecognized and uncorrected, can bias transfers (Rosenberger and Johnston, 2009).

Recognizing challenges to benefit transfer caused by a lack of adequate data and appropriate recording of primary research, a number of authors have called for additional emphasis into the provision of high quality, well-annotated empirical estimates of non-market values (e.g. Loomis and Rosenberger, 2006). However, these authors also note the general lack of academic incentives for research that does not introduce new methods or theories (e.g. Smith and Pattanayak, 2002; Rosenberger and Johnston, 2009). There is a related recognition that improved reporting, documentation and dissemination of study methods and data would provide a means to conduct more valid transfers (Loomis and Rosenberger, 2006). However, while these concerns may be broadly recognized, practical solutions have yet to be implemented.

It is not simply a lack of data and information that leads to the varying performance of benefit transfers. Many determinants of transfer validity and error are known by and under the direct control of the analyst. For example, choice over transfer method (function versus unit value), corrections for observable differences (e.g. population attributes, cf. Barton, 2002; Morrison *et al.*, 2002; Morrison and Bennett, 2004), and inferences based on available information (e.g. site similarity, cf. Johnston, 2007; conservatism or quality of original estimate, cf. Morrison, 2001) are part of the science of conducting benefit transfers. However, beyond general areas of consensus, there is relatively little empirical analysis quantifying specific and systematic relationships between the attributes of benefit transfer (e.g. transfer method, site attributes etc.) and transfer error (Rosenberger and Phipps, 2007). While exceptions exist, overall the literature provides little information regarding *specific* approaches that may be taken to minimize transfer error – or improve validity – in various contexts.

The debate over the suitability of benefit transfer in many ways parallels earlier debates regarding the suitability of stated preference methods for public policy use (cf. Arrow *et al.*, 1993; Hanemann, 1994). In the case of MA, for example, practitioners emphasize the empirical performance of MA derived transfer functions, statistical and other means to improve their performance (e.g. best practice guidelines), and the lack of broadly applicable alternatives with demonstrably superior performance (Nelson and Kennedy, 2009; Rosenberger and Johnston, 2009). In contrast, critics emphasize such issues as the lack of a micro-theory foundation, challenges involved in reconciling information across studies and in the associated interpretation of MA results, ambiguity with regard to the treatment of methodological covariates within MA benefit transfer, and examples in which the statistical or predictive performance of meta-regression models has been poor. Opinions offered on each side of the debate address different sets of advantages and disadvantages, leading to ambiguous guidance regarding the suitability of MA for benefit transfer. Similar controversies are found in various areas of transfer practice.

Other well-known limitations that might be addressed through greater interactions between researchers and policy analysts include the lack of best practice protocols

and guidelines.[32] Although the lack of such guidelines was noted by Smith (1992) and others over 15 years ago, there is still broad dissatisfaction with the state of the science and practice (Wilson and Hoehn, 2006). The divergence between the academic literature and current practice – as well as the lack of clear best practice guidance – imposes burden and uncertainty on the conduct of acceptable and defensible benefit transfers within the funding and time limitations characteristic of the policy process. Many methodological questions remain (Navrud and Ready, 2007). The many unsolved challenges of benefit transfer, together with the likelihood that such methods will continue to be an indispensable part of agency benefit–cost analyses, underscore the need for future research in this area.

Notes

1. While benefit transfer is most often discussed in the context of welfare estimates, other model outputs may be transferred. These can include such predicted quantities as site visits, service or commodity demand, or size of affected populations (e.g. Ben-Akiva, 1981; Bateman *et al.*, 2006; Zandersen *et al.*, 2007).
2. As described by Griffiths and Wheeler (2005), the Paperwork Reduction Act of 1995 requires government agencies to obtain Office of Management and Budget approval if information is to be collected from more than 10 non-Federal respondents. Approval often requires more than 180 days to complete, if granted at all, and must be obtained before research may commence. This requirement alone often precludes the use of original research studies for regulatory benefit–cost analyses.
3. There is a literature that addresses agency choice between primary studies and benefit transfer when either option is available (e.g. Allen and Loomis, 2008).
4. The use of more sophisticated methods alone, however, does not guarantee improvements in transfer validity or reliability (Navrud and Ready, 2007).
5. A *reliable* transfer is one in which the difference between value estimates generated at the study site and actual policy site values (i.e. as might be estimated using a primary study at the policy site) is small (Navrud and Ready, 2007); this is similar to the 'importance' criterion of Ben-Akiva (1981). In contrast, a *valid* transfer requires that model estimates from study and policy sites (e.g. parameter or value estimates) are statistically identical (Navrud and Ready, 2007); this is similar to Ben-Akiva's (1981) statistical-transferability criterion.
6. The literature, for example, provides opposing perspectives regarding the suitability and promise of meta-regression models as a benefit transfer tool – while many works express either implicit or explicit optimism regarding the suitability of meta-analysis as a means to estimate reduced form functions (e.g. Rosenberger and Loomis, 2000a, 2000b; Johnston *et al.*, 2005; Bergstrom and Taylor, 2006; Johnston *et al.*, 2006a; Rosenberger and Stanley, 2006; Moeltner *et al.*, 2007; US EPA, 2009), others caution against such applications (Poe *et al.*, 2001; Woodward and Wui, 2001; Smith and Pattanayak, 2002; US EPA, 2007).
7. For exceptions, see León *et al.* (2003).
8. Some other works also distinguish 'aggregation of existing estimates' or measure of central tendency transfers (Rosenberger and Loomis, 2003; Moeltner *et al.*, 2007).
9. Particular focus is applied to functions derived from techniques such as MA (e.g. Johnston *et al.*, 2005, 2006a; Bergstrom and Taylor, 2006; Rosenberger and Stanley, 2006; Moeltner *et al.*, 2007; Shrestha *et al.*, 2007; Johnston and Besedin, 2008;

Nelson and Kennedy, 2009; Rosenberger and Johnston, 2009), choice experiments (Morrison *et al.*, 2002; Morrison and Bennett, 2004; Van Bueren and Bennett, 2004; Jiang *et al.*, 2005; Hanley *et al.*, 2006b; Morrison and Bergland, 2006; Banzhaf and Smith, 2007; Columbo *et al.*, 2007; Johnston, 2007; Columbo and Hanley, 2008; Johnston and Duke, 2008, 2009a), Bayesian approaches (Atkinson *et al.*, 2002; León *et al.*, 2002; Moeltner *et al.*, 2007; Leon-Gonzalez and Scarpa, 2008; Moeltner and Rosenberger, 2008; Moeltner and Woodward, 2009) and preference calibration (Smith and Pattanayak, 2002; Smith *et al.*, 2002, 2006; Pattanayak *et al.*, 2007).

10. The VSL literature emphasizes unit value transfer, noting that the appropriateness of function-based adjustments (e.g. for life expectancy or income) is less clear (Mrozek and Taylor, 2002; Viscusi and Aldy, 2003; Brouwer and Bateman, 2005a; Ready and Navrud, 2007; US EPA, 2007).
11. In actual benefit transfer applications the true welfare value is unknown. For this reason, out-of-sample predictive performance, or convergent validity testing, has been the focus of past assessments of transfer validity. That is, transfer estimates of WTP are compared to a primary study estimate available for the site in question (Rosenberger and Stanley, 2006). A smaller difference between the calibrated transfer estimate and a primary estimate specific to the transfer site suggests increased transfer accuracy or reliability (Rosenberger and Phipps, 2007; Stapler and Johnston, 2009). This difference is often denoted generalization or transfer error. Studies quantifying transfer errors include Loomis (1992), Parsons and Kealy (1994), Bergland *et al.* (1995), Downing and Ozuna (1996), Kirchhoff *et al.* (1997), Brouwer and Spaninks (1999), Rosenberger and Loomis (2000b), Piper and Martin (2001), Shrestha and Loomis (2001), Vandenberg *et al.* (2001) Engel (2002), Chattopadhyay (2003), Johnston (2007), Columbo and Hanley (2008), Johnston and Duke (2008, 2009b) and Stapler and Johnston (2009) among others; see also the summaries of Brouwer (2000) and Rosenberger and Stanley (2006).
12. Studies evaluating transfers of choice experiment benefit functions include Morrison *et al.* (2002), Morrison and Bennett (2004), Van Bueren and Bennett (2004), Jiang *et al.* (2005), Hanley *et al.* (2006a, b), Columbo *et al.* (2007), Johnston (2007), Columbo and Hanley (2008) and Johnston and Duke (2008, 2009a). See also the review of Morrison and Bergland (2006).
13. Examples of studies evaluating MA benefit transfer functions include Brouwer (2000), Engel (2002), Florax *et al.* (2002b), Smith and Pattanayak (2002), Johnston *et al.* (2003, 2005, 2006a), Bergstrom and Taylor (2006), Rosenberger and Stanley (2006), Moeltner *et al.* (2007), Rosenberger and Phipps (2007), Moeltner and Rosenberger (2008), Moeltner and Woodward (2009) and Rosenberger and Johnston (2009).
14. Examples of single-study function transfers include Loomis (1992), Parsons and Kealy (1994) Loomis *et al.* (1995), Downing and Ozuna (1996), Feather and Hellerstein (1997), Kirchhoff *et al.* (1997), Bateman *et al.* (1999), Morrison *et al.* (2002), Morrison and Bennett (2004), Van Bueren and Bennett (2004), Jiang *et al.* (2005), Hanley *et al.* (2006a, b), Johnston (2007), Columbo and Hanley (2008) and Johnston and Duke (2009a), among many others.
15. These include functions derived from MA (e.g. Smith and Kaoru, 1990a, b; Smith and Huang, 1995; Loomis and White, 1996; Smith and Osborne, 1996; Rosenberger and Loomis, 2000a, b, 2001, 2003; Poe *et al.*, 2001; Florax *et al.*, 2002b; León

et al., 2002; Mrozek and Taylor, 2002; Bateman and Jones, 2003; Johnston *et al.*, 2003, 2005, 2006a, b; Bergstrom and Taylor, 2006; Rosenberger and Stanley, 2006; van Houtven *et al.*, 2007; Moeltner *et al.*, 2007; Rosenberger and Phipps, 2007; Moeltner and Woodward, 2009), preference calibration (e.g. Smith and Pattanayak, 2002; Smith *et al.*, 2002, 2006; Pattanayak *et al.*, 2007), choice experiments (e.g. Morrison and Bennett, 2000, 2004; Morrison *et al.*, 2002; Van Bueren and Bennett, 2004; Jiang *et al.*, 2005; Hanley *et al.*, 2006a, b; Morrison and Bergland, 2006; Columbo *et al.*, 2007; Johnston, 2007; Columbo and Hanley, 2008; Johnston and Duke, 2008, 2009a) and random utility models (e.g. Parsons and Kealy, 1994; Feather and Hellerstein, 1997; Kirchhoff *et al.*, 1997; Zandersen *et al.*, 2007). Bayesian approaches may also be used to estimate benefit functions; these include Bayesian estimation of meta-regression models (e.g. Moeltner *et al.*, 2007; Moeltner and Woodward, 2009), updating in which results of small pilot studies at the policy site are used to update prior results from study sites (e.g. Ben-Akiva, 1981; León *et al.*, 2002), and model averaging to combine information from different study sites (e.g. Leon-Gonzalez and Scarpa, 2008; Moeltner and Rosenberger, 2008).

16. Studies suggesting transfer functions perform best include Smith and Huang (1995), Desvousges *et al.* (1998), Engel (2002), Rosenberger and Loomis (2003), Moeltner *et al.* (2007), Rosenberger and Phipps (2007) and Stapler and Johnston (2009).
17. These include many works addressing statistical methods (e.g. Rosenberger and Loomis, 2000a, b; Brunsdon and Willis, 2002; Bateman and Jones, 2003; León *et al.*, 2007; Moeltner *et al.*, 2007; Leon-Gonzalez and Scarpa, 2008; Nelson and Kennedy, 2009), the potential impact of meta-regression model specification (e.g. Loomis and White, 1996; Rosenberger and Loomis, 2000a; Johnston *et al.*, 2003, 2005, 2006b; van Kooten *et al.*, 2007), the treatment of methodological moderator variables within MA and associated benefit transfer (e.g. Johnston *et al.*, 2006a; Moeltner *et al.*, 2007; Stapler and Johnston, 2009), the development of structural MA (Smith and Pattanayak, 2002), the conceptual and theoretical underpinnings of MA as a benefit transfer tool (e.g. Smith and Pattanayak, 2002; Bergstrom and Taylor, 2006; Rosenberger and Phipps, 2007), the role and amelioration of publication and selection biases (Florax, 2002; Smith and Pattanayak, 2002; Hoehn, 2006; Rosenberger and Stanley, 2006; Rosenberger and Johnston, 2009) and comparisons of MA benefit transfer to alternative transfer mechanisms (Smith and Huang, 1995; Sturtevant *et al.*, 1998; Engel, 2002; Shrestha *et al.*, 2007). Detailed discussion of many of these issues is provided by Smith and Pattanayak (2002), Bergstrom and Taylor (2006), Nelson and Kennedy (2009) and the various chapters of Florax *et al.* (2002a), among other sources.
18. Benefit transfer lacks an explicit micro-level theoretical foundation beyond the theory underlying primary data, although broad theoretical frameworks have been proposed (e.g. Moeltner *et al.*, 2007; Rosenberger and Phipps, 2007), and many types of function-based transfers might be considered to have at least a weak basis in economic theory (e.g. Bergstrom and Taylor, 2006).
19. The literature, however, does distinguish between different ways that one may establish statistical validity (Muthke and Holm-Mueller, 2004; Kristofersson and Navrud, 2005; Hanley *et al.*, 2006b; Johnston and Duke, 2008).
20. Further details of validity and error testing are provided by Brouwer and Spaninks (1999), Rosenberger and Stanley (2006) and Rosenberger and Phipps (2007), among others.

21. Studies that illustrate the importance of site correspondence include Boyle and Bergstrom (1992), Desvousges *et al.* (1992), Loomis (1992), Kask and Shogren (1994), Piper and Martin (2001), Rosenberger and Loomis (2001), Vandenberg *et al.* (2001), Barton (2002), Morrison *et al.* (2002), Morrison and Bennett (2004), Johnston (2007) and Columbo and Hanley (2008).
22. Examples include Desvousges *et al.* (1998), Morrison *et al.* (2002), Morrison and Bennett (2004), Van Bueren and Bennett (2004), Jiang *et al.* (2005), Hanley *et al.* (2006a, b), Johnston (2007) and Johnston and Duke (2009a).
23. The authors thank Kerry Smith for this comment.
24. For example, as noted by Johnston *et al.* (2005) and van Houtven *et al.* (2007), water quality improvements may be measured and defined using a variety of metrics, e.g. in terms of reductions in pollutants or improvements in ecosystem services.
25. For example, Smith and Pattanayak (2002) argue that MAs that combine estimates of Hicksian and Marshallian welfare measures should not be used to support benefit transfer, as such estimates are non-commensurable without a structural model that accounts for theoretical relationships. Similar sentiments are voiced by Nelson and Kennedy (2009). As an example of the difficulties associated with pooling estimates from different valuation methods (e.g. revealed and stated methods), Smith and Pattanayak (2002) cite Shrestha and Loomis (2001), whose metadata combine estimates from conventional travel cost, hedonic travel cost, random utility (RUM) and contingent valuation models. The theoretical definition of welfare measures derived from hedonic property value methods and stated preference approaches also differs (Blomquist, 1988; Johnston *et al.*, 2001), as do the broader theoretical definitions of stated and revealed value when non-use values are present (Freeman, 2003). Notwithstanding the particular example chosen, there are many MAs in the literature that combine estimates from various methodologies, with varying empirical methods used to account for associated theoretical expectations and patterns (Nelson and Kennedy, 2009).
26. For example, see Smith and Osborne (1996), Brouwer *et al.* (1999), Rosenberger and Loomis (2000a, b), Poe *et al.* (2001), Bateman and Jones (2003), Johnston *et al.* (2003, 2005, 2006a, b), Moeltner *et al.* (2007) and Stapler and Johnston (2009).
27. See note 25 above.
28. That is, for purposes of benefit transfer, levels for methodological variables are set at their mean values from the metadata.
29. Studies that explicitly discuss selection effects include Florax (2002), Smith and Pattanayak (2002), Bergstrom and Taylor (2006), Hoehn (2006), Rosenberger and Stanley (2006), Nelson and Kennedy (2009) and Rosenberger and Johnston (2009).
30. Spatial studies include Sutherland and Walsh (1985), Imber *et al.* (1991), Loomis (1996, 2000), Pate and Loomis (1997), Bateman *et al.* (2000, 2005, 2006), Johnston *et al.* (2002), Hanley *et al.* (2003), Mouranaka (2004) and Johnston and Duke (2009a), among others.
31. For example, transfer of hedonic property value model (HPM) results often involve either implicit or explicit spatial components, as property value impacts in primary HPM studies are often modeled as a function of distance from specified environmental, land use, or other features (e.g. Atkinson and Crocker, 1992; Johnston *et al.*, 2001; Chattopadhyay, 2003; Eshet *et al.*, 2007).
32. We note, however, that in some cases academic researchers are also policy analysts.

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