Chapter 11
Benefit Transfer

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Abstract Benefit transfer is a nonmarket valuation tool that is widely-used in a variety of decision contexts. Its primary role is deriving reliable estimates of value from prior research when new, original research is not feasible given time and resource constraints. This chapter begins by setting the development of benefit transfer in its historical context, which formally began in earnest in the early 1990's in response to an increased need for value measures in environmental and natural resource management and policy decisions. The two primary types of benefit transfer—value transfer and function transfer—are conceptually defined, including key steps when conducting them and examples of their empirical application. Sub-types of value transfers discussed include point estimate and measures of central tendency, and administratively-approved value transfers. Sub-types of function transfers discussed include benefit or demand function, and meta-regression analysis transfers. Reliability of benefit transfer is shown to be 45% transfer error for value transfers and 36% transfer error for function transfers. Criteria for minimizing transfer error rates in benefit transfers are provided to help guide practitioner decisions when using this tool.

Keywords Benefit transfer · Value transfer · Function transfer · Transfer error · Nonmarket valuation

Previous chapters of this book have described how to conduct an original non-market valuation study. However, original research may be time-consuming and expensive. What might an analyst do if a lack of time and/or funding prevents him or her from conducting an original study? For example, the U.S. Environmental Protection Agency is required to perform economic analyses on dozens of new

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P.A. Champ et al. (eds.), *A Primer on Nonmarket Valuation*,
The Economics of Non-Market Goods and Resources 13,
DOI 10.1007/978-94-007-7104-8_11

environmental regulations (e.g., water quality), but analysts are rarely given the time and budget to perform original studies (Griffiths et al. 2012). Thus, they must rely on existing data to compute the costs and benefits of programs. This chapter describes how existing data or summary statistics from previous research can be used in different decision contexts.

"Benefit transfer" is a colloquial term adopted by economists; it is defined as the use of existing data or information on nonmarket values in settings other than where they were originally collected. Benefit transfers are part of a broader family of economic data transfers. Sometimes an analyst may be interested in the price responsiveness of demand for certain goods or services. For example, what is the effect of a $3 fee increase on the demand for camping at a U.S. Forest Service campground, and what would be the total revenue generated from this fee increase? Here we are not necessarily interested in the total value of camping but in the change in use and potential revenue capture of a user fee program. Thus, information from nonmarket valuation studies can be used to inform policy and decision-making processes at various stages. It can be used in framing the policy context, evaluating policies (e.g., U.S. Environmental Protection Agency's assessment of the Clean Air Act [U.S. EPA 1997]), defining the extent of an affected market, prescreening of a natural resource damage assessment, and even determining whether original research is warranted.

While this chapter focuses on the use of benefit transfer to address valuation needs for nonmarket goods and services, the reader should not lose sight of its broader potential. The spirit of benefit transfer is that providing an estimate of the value of nonmarket resources using existing data may result in more balanced decision-making in situations where the direct monetary costs or opportunity costs of market commodities are known, but the nonmarket benefits are not (e.g., human health, public land recreation, ecosystem services, etc.). The purpose of this chapter is to provide guidelines to analysts to produce credible benefit transfer estimates. Before getting into the mechanics of benefit transfer, it is important to consider a historical context and a formal definition for the method.

11.1 A Historical Context

The first chapter of this book does a wonderful job of illustrating the need for value measures. Benefit transfer meets this need. Although economists have been estimating nonmarket values for more than half a century, the formal process of using benefit transfer to obtain estimates for nonmarket goods and services is only a few decades old. This short history reflects the age of nonmarket valuation.

The U.S. Army Corps of Engineers, the U.S. Bureau of Reclamation, and the U.S. Forest Service identified a need for estimates of recreation values for use in formal project evaluations and planning purposes. In 1973, the U.S. Water Resources Council published unit day value estimates of recreation activities for use in evaluating water-related projects. They updated these recreation value estimates in 1979 and 1983. In 1980, the U.S. Forest Service began publishing Resources Planning Act values (as per-person, per-activity-day estimates) for recreation (Rosenberger and Loomis 2001). Other Resource Planning Act values were published for timber, forage, minerals, and water. The U.S. Forest Service recreation estimates were driven by the Renewable Resources Planning Act of 1974, which required, among other things, a formal analysis of the costs and benefits associated with its programs.[1] Both the U.S. Water Resources Council's unit day values and the U.S. Forest Service's Resource Planning Act values were derived primarily from a combination of past empirical evidence, expert judgment, and political screening.

In the early 1980s, Freeman (1984) began the formal process of evaluating benefit transfer. He defined some specific conditions under which primary data could be transferable. In 1992, a section on benefit transfer was published in the journal Water Resources Research. Many of the top resource economists provided commentaries on the method in this special section. Collectively, the various articles suggested protocol, defined theory, identified needs, and presented new approaches.

Most benefit transfer exercises prior to the special section in Water Resources Research used a value transfer method that either transferred point estimates or measures of central tendency from original research or used administratively approved estimates. Loomis (1992) and Desvousges et al. (1992) proposed that more information, and therefore more robust benefit transfers, could be achieved with the transfer of entire demand (or benefit or willingness-to-pay) functions. Walsh et al. (1989, 1992) and Smith and Kaoru (1990) conducted meta-regression analyses of recreation values, potentially providing another approach to defining functions that could be used in benefit transfer.

The 1990s also were witness to the use of benefit transfers in the U.S. judicial system, primarily in natural resource damage assessments. While many of these early cases did not reach a jury verdict—instead concluding with negotiated settlements—the American Trading Transportation Company Inc. (ATTRANSCO) case was the first jury-defined verdict based on benefit transfer (see the text box that follows). The benefit transfer survived and informed the jury when setting the monetary value of recreation damages (Chapman and Hanemann 2001).

Since the early 1990s, new benefit transfer applications, tests, and methods were published in the literature. In 2000, the U.S. Environmental Protection Agency released its "Guidelines for Preparing Economic Analyses," in which steps for conducting benefit transfers were provided along with an approved estimate for the value of a statistical life (VSL) . These guidelines were updated in 2010 (U.S. EPA). In 2006, a special issue of the journal *Ecological Economics* reviewed state-of-the-art applications in benefit transfer. The focus of this special issue was primarily on function transfers, including value functions, meta-analysis functions, and structural preference functions. Conceptual issues in benefit transfers that go beyond a utility theoretical basis included the identification of various sources of

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[1]The Government Performance and Results Act of 1993 superseded some previous federal legislation requiring formal cost-benefit analyses of federal programs.

transfer error (Rosenberger and Stanley 2006), temporal stability of values (Brouwer 2006), and impacts of primary valuation methods on value estimates (Johnston et al. 2006). Other contributions to the special issue reviewed applications of choice experiments (Morrison and Bergland 2006) and international transfers (Ready and Navrud 2006), as well as illustrating applications of geographic information systems (Troy and Wilson 2006) and spatial distributions (Bateman et al. 2006).

In 2000, the European Commission published its Water Framework Directive that seeks to improve surface and groundwater quality in Europe (European Commission 2005; WATECO 2004). As part of this directive, river basin management plans are required to be spatially integrative and measure the costs and benefits of these plans (Hanley and Black 2006). The nonmarket valuation requirements of this directive may necessitate wide use of benefit transfer (Hanley et al. 2006a) including transfers that rely on international databases (McComb et al. 2006).

In 2010, Johnston and Rosenberger provided a comprehensive review of benefit transfer applications and issues. Their discussion included the general issues of commodity definition consistency, primary study methodologies, spatial patterns, temporal trends, international benefit transfers, and site similarity.

In 2015, Johnston et al. expounded on their earlier work and published an edited book dedicated to benefit transfer. This book is a comprehensive guide written for researchers and practitioners, covering the theory, concepts, methods and applications of benefit transfer in environmental and natural resource economics.

Benefit Transfer in Action Problem

What is the value of lost recreation due to the American Trader oil spill in the Southern California area in 1990 (Chapman et al. 1998; Chapman and Hanemann 2001)? The primary needs are an estimate of lost recreation days and a value per recreation day. The following is part of the information provided by the plaintiffs in the trial People ex rel. Department of Fish and Game v. ATTRANSCO Inc. et al., Orange County, Ca., Superior Court Case No. 64 63 39, 1997.

Approach

Lost recreation days: Used extensive, historical to derive a function predicting number of recreation days lost due to beach closures and impeded access due to oil spill and mitigation efforts.

Value per recreation day: Existing literature was reviewed, resulting in Bell and Leeworthy's (1986) study of beach recreation in Florida being selected as the best available match for benefit transfer of beach-related recreation in Southern California.

Results

Original estimates as reported in Chapman and Hanemann (2001; 1990 $)

	Lost days	Value per day ($)	Total lost value ($)
Loss during beach closure period			
General beach recreation	454,280	13.19	5,991,953
Loss outside beach closure period			
General beach recreation	278,986	13.19	3,679,825
Total beach recreation loss			**$9,671,778**

This estimate was assumed to be conservative based on the income differential between Florida residents and Orange County, California residents. During the trial, expert economists for the plaintiffs and defendants testified about methodology, assumptions, and the results of different analyses to address areas of disagreement about data, countervailing factors, and modeling assumptions. In 1997, the jurors awarded the trustees $12.7 million in recreation damages, including estimates for beach, surfing, boating, fishing, and whale watching recreation, plus a civil liability of $5.3 million under the California Water Code, for a total award of $18 million.

11.2 Benefit Transfer Defined

When conducting an original nonmarket valuation study is not possible, values and other information from an existing study (or studies) can be used to estimate the value of the good or policy of current interest. Benefit transfer is the adaptation of existing value information to a new context. The context of the existing information is often referred to as the study site, and the benefit measure for the study site is defined as V_S.[2] The policy site, or the context for which information is needed, is defined as V_P. Ultimately, estimates of V_{Pj} for policy site j are derived from original research conducted at the study site i (V_{Si}). Study site values (V_{Si}) become transfer values (V_{Tj}) when applied to policy site j. However, as with any approximation, there is some error ε that needs to be minimized through the benefit transfer process.

$$V_{Si} = V_{Tj} + \varepsilon = V_{Pj}. \tag{11.1}$$

Original research provides content- and context-specific information regarding the policy site(s). This is because the target of original research is to address a specific need in a specific context. In the case of benefit transfer, the original

[2] V is used to denote value information or data and can consist of measures of benefits or costs, resource quantities or qualities, population characteristics, and other relevant information such as elasticities, dose-response effects, regression coefficients, and t-values.

research site and the policy site are often not the same (i.e., $i \neq j$). Therefore, the benefit transfer process must discuss the content- and context-relevant information of the study site and policy site in order for the user of the benefit transfer to have some idea of how well the study site matches the policy site. Ideally, the information transferred is relevant to the policy site context. Only in rare circumstances will the transferred information be specific to the policy site. Specificity would occur only if the study site and policy site were identical on all dimensions. In deciding whether the benefit transfer method is applicable, the analyst is trying to determine whether V_{Si} is similar enough in context to make a valid inference of V_{Pj}. This chapter discusses guidelines and approaches on how estimates of V_{Si} can be used to estimate V_{Pj} or the method of benefit transfer.

Now that a formal definition and a historical context of benefit transfer has been provided, the next section will clarify some of the terms used above, such as point estimate transfer, benefit function transfer, and meta-regression analysis transfer.

11.3 Modeling and Applying Benefit Transfer

Several benefit transfer methods have been developed to meet the needs for estimates of $V_{Pj,}$ or the value at policy site *j*. These approaches are broadly classified as (1) value transfer and (2) function transfer. Value transfer involves the direct application of summary statistics from original research to a policy context. Function transfer involves the application of a statistical function that relates the summary statistics of original research to the specifics of the study site. In addition to providing the details of these approaches, the decision criteria an analyst could employ to choose the method to use are presented.

11.3.1 Value Transfer

Value transfer is the direct application of original research summary statistics (such as per-unit measures of willingness to pay [WTP], measures of elasticity, or other measures of marginal effects) to a policy site. There are essentially three approaches to conducting value transfers: (1) transfers of point estimates, (2) transfers of measures of central tendency, and (3) transfers of administratively approved estimates.

11.3.1.1 Point Estimate and Central Tendency Transfers

In some situations, a value transfer entails simply using a single study site estimate or an average of several estimates as the transfer value for a policy site. We call these types of value transfer a point estimate transfer or a measure of central

Table 11.1 Steps in conducting a point estimate value transfer

Step 1	Define the policy context (Q_{Pj}). This definition should include various characteristics of the policy site, what information is needed, and in what units
Step 2	Locate and gather original research outcomes (V_{Si}). Conduct a thorough literature review and obtain copies of potentially relevant publications
Step 3	Screen the original research studies for relevance ($Q_{Si} = Q_{Pj}$). How well does the original research context correspond to the policy context? Are the point estimates (V_{Si}) in the right units or can they be adjusted to the right units? What is the quality of the original research?
Step 4	Select a point estimate or range of point estimates (V_{Si}). This point estimate or range of point estimates should be selected on the best match between Q_{Pj} and Q_{Si}
Step 5	Transfer the point estimate or range of point estimates (V_{Tj}). Aggregate the point estimate to the policy site context by multiplying it by the total number of units, which provides a total value estimate for the good or service at the policy site

tendency (i.e., mean or median value) transfer, respectively. These transfers use measures of V_{Si}, given the context of study site i (Q_{Si}; e.g., location, population, resource changes at study site), to estimate the needed measure (V_{Pj}) for policy site j, given the context of the policy site (Q_{Pj}; e.g., location, population, resource changes at the policy site):

$$V_{Si}\big|Q_{Si} = V_{Tj} + \varepsilon = V_{Pj}\big|Q_{Pj}. \tag{11.2}$$

Point estimate transfer can be done using a single most similar site study value if there is one site that matches very closely or an average of site values if there is not a good single-site match. Given that there is unlikely to be a "near perfect" match between the study site and the policy site and if there are multiple values reported in the literature, then a range of estimates should be transferred to provide bounds on the value estimate at the policy site. In addition, it is recommended that confidence intervals be constructed around point estimate transfers when possible. This provides additional information regarding the precision of the study site measures. And furthermore, point estimates should be adjusted for differences in observable attributes of study and policy sites (e.g., adjusting the WTP value by measurable income differences; Ready and Navrud 2007).

Table 11.1 provides an overview of the steps in conducting a point estimate transfer. To illustrate this approach, a hypothetical application is provided. The Klamath River in Southwest Oregon is protected through designation as a national wild and scenic river by act of Congress in 1968. The river is 263 miles in length and is important to the region for its whitewater rafting, fishing, and natural beauty. However, the river also contains dams for the purposes of electricity generation and capturing water for agricultural irrigation. A coalition of tribes, conservationists, landowners and the local dam operator have come to an agreement that these dams should be removed. The hypothetical application of benefit transfer is to derive an estimate of the value of whitewater rafting for use in a benefit-cost analysis of the increased value of whitewater rafting due to dam removal.

The policy context in our example is defined as (1) the Klamath River in the Pacific Northwest, (2) use-value estimates for private (i.e., not commercially guided) whitewater rafting or kayaking, and (3) estimates of willingness to pay (i.e., consumer surplus) per person, per day. Given the defined policy context, a literature search was conducted. When conducting a literature search, the analyst should consider consulting experts, making inquiries on e-mail Listservs, and contacting relevant government agencies with management responsibilities for the resource of interest, in addition to keyword searches of electronic databases such as EconLit, AgEcon Search, and Google Scholar. The information the analyst seeks may not be provided in the peer-reviewed, published literature, so these contacts can help locate the "gray literature," such as theses and dissertations, unpublished working papers, conference proceedings, and agency reports. The gray literature may also help overcome the problem of selection bias and increase the number of estimates from which to choose (Stanley 2001; Rosenberger and Stanley 2006; Rosenberger and Johnston 2009).

The literature search could begin with keyword searches in the American Economic Association's EconLit database, Google Scholar, and Environment Canada's (1998) Environmental Values Reference Inventory Database. However, a related asset is the Recreation Use Values Database (Rosenberger 2011), which is a compilation of recreation use-value studies in the United States and Canada published through 2006. In addition to the literature referenced in the database, a working paper is added that estimated the value of whitewater rafting on a river in Colorado. Several studies located in the original search for constructing the database were discarded because they did not provide value estimates, which is the information sought after in this benefit transfer exercise.[3]

The initial search of the Recreation Use Values Database and other databases/tools resulted in 16 studies providing a total of 66 estimates of whitewater rafting or kayaking. Further evaluation of each of the studies and their estimates resulted in our discarding two studies and 14 estimates, primarily because they used nonstandard travel cost modeling procedures that lead to noncomparable outcomes. Table 11.2 lists some of the characteristics of the remaining 14 studies and 52 estimates of whitewater rafting or kayaking on 10 different rivers in the U.S. The two studies in Oregon for the Rogue River arguably provide the most similar site estimates of value given that the Klamath River, the policy context, is in the same general region as the Rogue River. In this case, the value per person, per day of private whitewater rafting or kayaking on the Rogue River is worth between $12 and $32 (in 2013 dollars). However, these estimates are based on a study that collected data nearly three decades ago, prior to dam removal on the Rogue River.

Alternatively, an analyst could select the most similar site based on measurable characteristics of each river. For the Klamath River, the average instream flow at its

[3]Studies that do not report any data or insufficiently report data may not be of use. Other factors can include a poor match between data needs for the policy site context (what is affected and how impacts are measured) and the context of the study site data. Boyle and Bergstrom (1992) describe how data may not be relevant for benefit transfers in general.

Table 11.2 Whitewater rafting/kayaking studies, United States (2013 $)

State/Region[a]	Rivers	Year studied	No. of studies	No. of estimates	Mean ($); (s.e.)	Range ($)
Maine	Dead	1994	1	4	41.84 (3.57)	31-47
Georgia, South Carolina	Chattooga	1979, 1993	2	8	242.64 (58.20)	21-457
North Carolina	Nantahala	1993	1	6	228.34 (24.84)	142-305
Idaho	Saint Joe, Salmon, Snake	1969, 1971, 1979, 2004	3	5	167.88 (81.29)	51-483
Utah	Colorado	1977	1	1	29.52 (–)	–
Colorado	Cache la Poudre	1978, 2010	2	3	77.18 (19.36)	39-99
Arizona	Colorado	1985, 1998	2	15	204.84 (30.73)	12-380
Wyoming	Snake	2004	1	2	219.61 (120.14)	99-340
California	Tuolumne	1982	1	2	108.00 (20.39)	88-128
Oregon	Rogue	1984	2	6	20.33 (2.82)	12-32
Mountain Region	5	–	8	26	177.40 (25.69)	12-483
Pacific Region	2	–	3	8	42.25 (15.00)	12-128
West Region	7	–	11	34	145.60 (22.20)	12-483
Total	10	–	14[b]	52	$162.09 (18.49)	$12-483

[a]Regional estimates are supersets of states' estimates
[b]The number of studies does not add up due to two studies evaluating rivers in multiple states

mouth is 17,010 cubic feet per second (cfs); it has a change in elevation of 4,090 feet; and it is 263 miles in length. The most similar river based on instream flow at its mouth is the Colorado River, with potential transfer estimates ranging from $12 to $379 per person, per day for whitewater recreation. The most similar river based on elevation change is the Nantahala River in North Carolina, with potential transfer estimates of $190 to $456 per person, per day for whitewater recreation. And the river most similar in length is the Rogue River, with potential estimates ranging from $12 to $32 per person, per day for whitewater recreation. None of the rivers in the Recreation Use Values Database best match the Klamath River policy site on more than one measurable characteristic. However, if studies are filtered by the region they focus on, then the Rogue River remains the most similar site.

Table 11.3 Whitewater rafting/kayaking studies, United States (2013 $), 20% trimmed mean

Region	No. of studies	No. of estimates	Mean ($); (s.e.)	Range ($)
Mountain Region	6	17	140.15 (20.39)	39-294
Pacific Region	2	3	82.53 (28.06)	32-128
West Region	8	20	131.51 (18.23)	32-294
Total	**10**	**32**	**$142.63 (15.42)**	**$31-294**

However, the two characteristics of region and river length are not sufficient in themselves to declare the Rogue River as the most similar site. In addition, comparison with the broader literature does lead to some concern about relying solely on the Rogue River value estimates given they are at the lower bound of the distribution across all value estimates for whitewater recreation. This example suggests that selecting the most similar site is not necessarily a simple matter given that different sites may match on different characteristics.

A measure of central tendency transfer involves using a mean, median, or other measure of central tendency based on all or a subset of original research outcomes. Continuing with the previous example of estimating the value of a private whitewater rafting or kayaking day on the Klamath River, note that the first three steps are the same as the point estimate transfer. The next step is to calculate a measure of central tendency for all of the estimates. In this case, the information from all studies is used, thus minimizing concerns about point estimate transfers discussed previously. The average of all 52 estimates is $162 per person, per day (Table 11.2), an order of magnitude larger than the site-specific estimates discussed previously. The range is from $12 to $483. If the average value is restricted to the Western Census Region due to concerns about comparability of whitewater experiences in the Eastern U.S., then the average of the remaining 34 estimates is $146, still with the same range in estimates. However, if the region is further restricted to the Pacific Census Division, the average of the remaining eight estimates—which is the Rogue River estimates combined with two estimates for the Tuolumne River in California—is $42, with a range of $12 to $128 per person, per day.

Furthermore, analysts should be concerned about the vagaries of random sampling and modeling assumptions on the range of estimates from the literature. Objectively trimming the tails of the distribution of estimates from the literature reduces the effect of very low and very high estimates on the calculated average value. For example, Table 11.3 reports summary statistics from trimming 20% of the observations (10% from each tail of the distribution). This technique reduces the number of studies from 14 to 10 and the number of estimates from 52 to 32. Specifically, five of the six Rogue River specific estimates are removed because they fall in the 10% trimmed from the lower tail, and the remaining estimate defines the limit of the lower tail. The mean value from the 32 estimates is $143 per person, per day, which is not statistically different from the original average value for the entire data. However, the Pacific Census Division estimate is now $82 per person, per day, due to the increased influence of the Tuolumne River study in California. The same arguments that were made regarding the effect of the point estimate benefit transfer measure on the policy process can be made here. That is, if the estimate, when combined with other values associated with dam removal, is substantially greater than or smaller than the costs, then the benefit transfer exercise has added information to the policy process. If a more precise estimate could change the project or policy decision, then original research is warranted.

11.3.1.2 Administratively Approved Estimate Transfer

Administratively approved estimate transfer is arguably the simplest approach to benefit transfer if these measures are available and match your data needs. In the U. S., federal agencies commonly use administratively approved estimates in assessing management and policy actions. The U.S. Forest Service has used Resource Planning Act values since 1980 (Rosenberger and Loomis 2001). These Resource Planning Act values are provided for groups of outdoor recreation activities and Forest Service regions of the country. Similarly, the U.S. Bureau of Reclamation and U.S. Army Corps of Engineers have relied on the U.S. Water Resources Council's unit day values of recreation use for decades (U.S. Water Resources Council 1973, 1979, 1983) and continue to do so today. The most significant—and controversial—administratively approved estimate is in the form of the value of statistical life (VSL). The VSL is a statistical measure of income or wealth that would be traded off for a small change in the probability or risk of death; conversely, it measures the tradeoff between money and life. The U.S. Environmental Protection Agency has published its recommended "default central 'value of statistical life' (VSL) of $7.9 million (in 2008 dollars) to value reduced mortality for all programs and policies" (U.S. EPA 2010, pp. 7-8).

Administratively approved estimates are derived from empirical evidence in the literature, expert judgment, and political screening. There are two main issues associated with using administratively approved estimates. First, the criteria used in the political screening process are unknown. This process may ignore some empirical evidence or use arbitrary adjustment factors. The second issue is that administratively approved estimates are only updated occasionally. Therefore, estimates may not reflect the latest empirical evidence. One distinct advantage of using administratively approved estimates for agency purposes is that the estimates have survived the political screening process.

The administratively approved transfer can be defined as

$$V_{SA} = V_{Tj} + \varepsilon = V_{Pj}, \tag{11.3}$$

where V_{SA} is the administratively approved measure that is transferred to provide the value at policy site j (V_{Pj}). Table 11.4 outlines the steps involved in conducting an administratively approved estimate transfer. Analysts should not use these measures solely on the basis that the U.S. Forest Service, U.S. Army Corp of Engineers, or U.S. Environmental Protection Agency uses them. Administratively approved estimates are developed to address certain agency needs, which may or

Table 11.4 Steps in conducting an administratively approved estimate transfer

Step 1	Define the policy context (Q_{Pj}). This definition should include various characteristics of the policy site, what information is needed, and in what units
Step 2	Obtain administratively approved estimate (V_{SA}). These estimates are typically published by an agency. Check with the relevant agency's policy or research division
Step 3	Transfer the administratively approved estimate (V_{Tj}). Aggregate the estimate to the policy site context by multiplying it by the total number of units, providing a total value estimate for the good or service at the policy site

may not match well with the analyst's needs. The analyst should understand how and why these values were developed and then determine whether they meet his or her needs.

U.S. Environmental Protection Agency's uses of its administratively approved VSL central estimate include the Clean Air Interstate Rule, the Nonroad Diesel Rule, and the Stage 2 Disinfectants and Disinfection Byproducts Rule (see U.S. EPA, 2010, for links to these rules and other information regarding VSLs). While the VSL estimate is approved for use in important policy developments, it is based on 26 studies conducted between 1974 and 1991, primarily using hedonic wage methods across a variety of populations and types of death. The Agency is aware of limitations and implicit errors associated with this VSL estimate, including measurement error issues in original studies and the age of studies behind the estimate; however, until it updates the studies used or develops other methods, this estimate continues to be recommended and used in practice.

11.3.2 Function Transfer

Function transfers are more technically oriented than value transfers. They involve the transfer of functions or statistical models that define relationships between value estimates and study site characteristics. Some of these models were introduced previously in this book. Function transfers can be categorized as demand (or benefit or WTP) functions[4] or meta-regression analysis functions.

Function transfers are generally considered to perform better than value transfers, an issue investigated in more detail at the end of this chapter. This increased accuracy is because function transfers may be tailored to fit some of the characteristics of the policy site. Value transfers, on the other hand, are invariant to most differences between the study site and the policy site. However, as previously noted, value transfers can be adjusted for some attributes (e.g., income) that differ between the study site and policy site.

[4]Other functions include dose-response or production functions, especially prevalent in the health sciences literature.

11.3.2.1 Demand or Benefit Function Transfer

Demand or benefit function transfers are based on the premise that the study site estimate for site i (V_{Si}) is a function of characteristics of the study site context (Q_{Si}; e.g., location, physical features, and climate) and other explanatory variables (Z_{Si}; e.g., sociodemographics, attitudes):

$$V_{Si} = Vf(Q_{Si}, Z_{Si}). \tag{11.4}$$

Other chapters in this book provided reasons why and how to estimate WTP and demand functions using a variety of nonmarket valuation tools. This additional information may be used to take advantage of these relationships when conducting benefit transfer. Rather than relying solely on value transfers, precision may be gained from incorporating these relationships in benefit transfer. A value transfer requires a strong similarity between study sites and policy sites, which may not always be the case. The invariance of value transfer measures to other relevant characteristics of a policy site may make these transfers insensitive or less robust to significant differences between the study site and the policy site. Therefore, the precision of benefit transfer can be increased if value estimates are adapted via a function to fit the specifics of a policy site, under conditions that the underlying structural relationships (e.g., preferences, behaviors) are stable across sites.

The beginning steps to conducting a demand or benefit function transfer are the same as for a value transfer with the exception that additional information is required from publications. Some form of a function that models the statistical relationships between the summary measures of interest and characteristics of the original research effort—including characteristics of the study site and the study population—must be reported if a study is to be used in a benefit function transfer. The analyst will ultimately adapt this function to specific characteristics of the policy site, thereby predicting values for the policy site. A near-perfect match between the study site and policy site is not required because the analyst can potentially compensate for these differences in function transfers.

The demand or benefit function transfer can be defined as

$$Vf_S\left(Q_{S|Pj}, Z_{S|Pj}\right) = V_{Tj} + \varepsilon = V_{Pj}. \tag{11.5}$$

The policy site measure (V_{Tj}) is derived from the study site function (Vf_S) adjusted to the characteristics of the policy site ($Q_{S|P}$ and $Z_{S|P}$). This is why, in Step 4 of Table 11.5, summary data are gathered on the policy site for as many of the independent, or explanatory, variables in the model as possible. This information is used to tailor or adapt the study site function to the policy site context.

The following is an example of a benefit function transfer. This example is simplistic,[5] but it illustrates several issues: (1) application of benefit function

[5]Another reason this example is simplified is that it deals with a benefit function, which is a direct estimation method. As such, it directly models the relationship between WTP and independent

Table 11.5 Steps in conducting a demand or benefit function transfer

Step 1	Define the policy context (V_{Pj}). This definition should include various characteristics of the policy site (Z_{Pj}), what information is needed, and in what units
Step 2	Locate and gather original research demand or benefit functions (Vf_S). Conduct a thorough literature review and obtain copies of potentially relevant publications
Step 3	Screen the original research studies for relevance ($Q_{Si} = Q_{Pj}$). How well does the original research context correspond to the policy context? What is the quality of the original research? And most importantly, is a demand or benefit function (Vf_S) provided?
Step 4	The demand or benefit function (Vf_S) provided by original research has several independent or explanatory variables associated with it. Gather summary data on the policy site (Z_{Pj}) for as many of the variables in the model as possible
Step 5	Predict the policy site benefit estimate (V_{Tj}) by multiplying the summary statistics reflecting the policy site by the regression coefficients in the transfer function ($Q_{S\|P}$ and $Z_{S\|P}$). This results in a tailored estimate for the policy site
Step 6	Aggregate the tailored estimate to the policy site context by multiplying it by the total number of units, providing a total value estimate for the good or service at the policy site

transfers, (2) effect of multisite data modeling on transfer accuracy, and (3) validity testing between value and function transfer approaches. Assume that the value of interest is for improving groundwater quality used for drinking to a very safe level in a small Northeastern town. A literature search identified several groundwater quality improvement studies. From among all of the studies identified, the following study seems to provide the most relevant benefit function.

A case study by VandenBerg et al. (2001) estimates the benefits of improving groundwater quality used for drinking to a "very safe" level in 12 towns in New York, Massachusetts, and Pennsylvania. The study also tests the relative accuracy of two benefit transfer approaches. The authors used a contingent valuation survey. Mean WTP per household, per year was calculated for each of the 12 towns using the survey responses. This mean WTP is treated as the benchmark or known estimate (V_{Pj}) for each town j to which the transferred estimate (V_{Ti}) is compared. They used the estimate derived for each of the other 11 towns (study sites) as possible point measures to transfer to the 12th town (the policy site).

To perform the benefit function transfer, a protocol first used by Loomis (1992) is employed whereby all of the survey data except for one town were pooled and a WTP equation was estimated. The independent variables of this function were then set at the levels for the "*n*th," or excluded, town in order to predict mean WTP per household at this excluded town. In all, 12 benefit function models were estimated.

(Footnote 5 continued)

variables. Other models, such as demand models, may not be as easily adjusted or may not be amenable to adjustment depending on how the models are developed, including functional form (Adamowicz et al. 1989).

VandenBerg et al. (2001) report a benefit function model based on pooling the data for all 12 towns, which will be used later in this example.

A sufficient number of explanatory variables that account for relevant differences in the site attributes (e.g., size, quality) between the study site and policy site, as well as key differences in demographics (e.g., income, average age, education) should be included. In the VandenBerg et al. (2001) example, explanatory variables included demographics such as education and income. These types of data, which are available from secondary sources, allow the analyst to control for differences in demographics between the study site and the policy site. However, if these data are not part of the demand or benefit function at the study site, then adjusting for these particular expected differences between the two sites is not feasible. Benefit transfer estimates using an incomplete benefit transfer function adjustment are likely, on average, to be more accurate than value transfers with point estimates from study sites that are most similar to the policy site.

VandenBerg et al. (2001) also included a series of responses to risk perceptions, perceptions regarding current safety of water, and perceived likelihood of future contamination. These variables were statistically significant and contributed to the explanatory power of their models. However, they make real-world benefit transfer difficult because the analyst would need to know the perception variables for the policy site. Typically, these perception variables are not available from secondary sources and would require a survey of households at the policy site. Benefit function transfer reduces the amount of information needed for valuation and, thus, only a simple survey would need to be conducted in order to collect the desired information. In real-world applications, the analyst may simply need to use the original study site perceptions, noting the assumption being made that these are the same between the study and policy site populations. Ideally the analyst would like to have explanatory variables in the benefit transfer function that are available at both the study site and the policy site. Thus, when the analyst is choosing among possible benefit functions, he or she should keep in mind whether information is available to support a more detailed benefit function transfer versus a simpler but less data-demanding benefit function.

VandenBerg et al. (2001) provide a benefit function (mean WTP per household, per year) based on pooling all the data for the 12 towns (Table 11.6). This model contains several dummy variables that would enable adjustment for differences between the study and policy populations. No variables that identify physical characteristics of the sites are included in the model. Most of the variables would require conducting a survey at the policy site in order to determine how its population differs from the populations used to estimate the model. However, they do provide summary statistics for most of the variables for each town in the data set; typically, this is what the benefit transfer analyst would rely on in performing a benefit function transfer. The last two columns in Table 11.6 show the adjustments to this function to reflect characteristics of one of the towns.

In order to tailor or adapt VandenBerg et al.'s (2001) benefit function to the policy site, the regression coefficients from the model are multiplied by measures of the variables for the policy site to derive the partial WTP associated with each of the

Table 11.6 Ordinary least squares regression model for groundwater quality protection, Dependent Variable = mean willingness to pay per household, per year, $N = 667$

Variable	Regression coefficient	Policy site measure	Partial WTP
Constant	−29.68	1	−29.68
Perception of contamination (0, 1 = no experience)	−23.48	1	−23.48
Perception of contamination (0, 1 = don't know)	−26.96	0.24	−6.47
Likelihood of future contamination (0, 1 = likely or very likely)	17.51	0.5	8.76
Likelihood of future contamination (0, 1 = not sure)	9.41	0.5	4.70
Interest in community water issues (0, 1 = mild to no interest)	−20.66	0.5	−10.33
Interest in community water issues (0, 1 = interested)	−11.15	0.5	−5.58
Perceived water quality (0, 1 = unsafe or somewhat safe)	29.92	0.5	14.96
Perceived water quality (0, 1 = safe)	21.07	0.5	10.54
College degree (0, 1 = has college degree)	−17.51	0.24	−4.20
Some college (0, 1 = has some college but no degree)	−15.72	0.24	−3.77
Average risk perception (3-question composite; 1 = safe to 5 = unsafe)	9.91	4	39.64
Number of perceived potential contamination sources	2.56	3.17	8.12
Trust in government and organizations (9-question composite; 1 = do not trust to 3 = trust)	15.67	1.91	29.93
Household income ($/year)	0.0008	45,500	36.40
Total mean WTP = $\sum$(column 2 $\times$ column 3) =			**$69.54**

Note Adjusted $R^2 = 0.15$
Adapted from VandenBerg et al. (2001)

variables. See VandenBerg et al. (2001) for a full account of the different variables and site measures. Values for the independent variables are for the Horsham, Pennsylvania, policy site.

The first variable in the model, the constant or intercept term, is transferred in full to the policy site. The next eight variables measure various factors associated with perceived contamination and water safety and community contamination issues. Given this type of information is likely not available for a policy site, associated variables would be adjusted based on reported values for the study site. For more details regarding these variables, see VandenBerg et al. (2001).

Assigning values for the policy site to the remaining variables in the model is relatively straightforward. The college education variables do not perfectly match with the summary statistic reported for the policy site. The policy site reports that 48% of the town is college-educated based on the survey responses. What proportion of this 48% has a college degree versus some college is unknown. Because the regression coefficients for the education dummy variables are similar, one way to capture the effect of education is to split this proportion in half, which transfers 24% of each education variable for a total 48% effect of college education.

For the policy site, VandenBerg et al. (2001) report that the mean average risk perception is 4, the mean number of perceived potential contamination sources is 3.17, the mean trust is 1.91, and mean household income per year is $45,500 for Horsham. Thus, multiplying the respective coefficients by these reported levels for the policy site provides the partial WTP effects of these variables.

Summing all of the partial effects listed in the last column of Table 11.6 results in $69.54 in total mean WTP per household, per year for the policy site town of Horsham, Pennsylvania. The actual mean WTP per household, per year for Horsham is $67.45, based on site-specific data. The benefit function transfer estimate is well within a 95% confidence interval for the actual value for the site and has a percent transfer error of about 3%.

11.3.2.2 Meta-Regression Analysis Function Transfer

Another function transfer approach that is gaining application is the meta-regression analysis function transfer. Demand or benefit function transfers rely on statistical relationships defined for certain variables based on a single study. Meta-regression analysis summarizes and synthesizes outcomes from several studies. There are essentially two approaches to meta-regression analysis: (1) pooling the actual data from multiple studies and (2) using summary statistics, such as value estimates, from multiple studies. The latter is more prevalent and the focus of this section.

Meta-regression analysis overcomes some of the issues related to demand or benefit function transfers. Namely, it is possible to statistically explain the variation found across empirical studies (as found in the whitewater rafting or kayaking example). Some of this variation in value estimates may be due to identifiable characteristics among the different studies themselves, such as valuation method, survey mode, geographic location, and so forth. These characteristics are not explanatory variables in the original studies because they define the context of original research and are, therefore, constant in original research. Meta-regression analysis may be able to discern the individual study effects some of these variables may have on estimated values.

Meta-regression analysis has traditionally been concerned with understanding the influence of methodological and study-specific factors on research outcomes and providing summaries and syntheses of past research (Stanley and Jarrell 1989). The first two meta-analyses on environmental and natural resource economic studies were by Smith and Kaoru (1990) on travel cost studies of recreation benefits and by Walsh et al. (1989, 1992) on outdoor recreation benefit studies. Since then, meta-analysis has become a rapidly expanding method, although not always aimed at benefit transfer applications. Nelson and Kennedy (2009) identify and evaluate more than 130 distinct applications of meta-analysis in environmental economics, with the majority conducted since 2003.

The dependent variable in a meta-regression analysis is a summary statistic from each individual study, such as a value estimate, elasticity, or other measure. The independent or explanatory variables are characteristics of the model, survey design, and data of the original studies. The interstudy variation in research outcomes may be explained by modeling the characteristics that are typically held constant within an individual study, such as valuation methodology, survey mode, time, and physical attributes of the study site.

A basic premise of meta-regression analysis is the existence of an underlying valuation function, of which original research studies are independent random draws. This premise is likely false for many literatures (Rosenberger and Johnston 2009). The draws are not random because a reason exists for conducting original research on some sites and not others (selection bias). Peer-review screening for statistically significant results in journals (publication bias) is also an issue. The draws are probably not independent due to multiple estimates from single studies or

Table 11.7 Steps in conducting a meta-analysis function transfer

Step 1	Define the policy context (Q_{Pj}). This definition should include various characteristics of the policy site, what information is needed, and in what units
Step 2	Develop a standard database structure. Conduct a thorough literature review and obtain copies of potentially relevant publications. Develop a master coding strategy that allows for consistently coding as much information as possible regarding each study. This information includes the dependent (V_{Si}) and independent variables in the original analysis, methodological (M_{Si}) and other study characteristics (Z_{Si}), source of the study, and authors of the study
Step 3	Before coding the individual studies, screen the original research studies for relevance ($Q_{Si} = Q_{Pj}$). Reduce the literature search outcomes to include those studies containing relevant empirical estimates, tests, or findings
Step 4	Choose and reduce the summary statistic (V_{Si}) to a common metric. The summary statistic would be the primary information needed for the policy site. Reduction to a common metric may include reducing all empirical estimates to the same unit (e.g., annual basis). This summary statistic will serve as the dependent variable in the meta-analysis regression
Step 5	Choose the independent variables (Z, M). These variables are those characteristics of the individual studies that are hypothesized to be important or consequential to differences in the summary statistics
Step 6	Conduct the meta-regression analysis ($Vf_S(Q, Z, M)$). The summary statistic will serve as the dependent variable, and the independent variables will serve as the explanatory variables. The purpose of meta-regression analysis is to explain the variation in the dependent variable across studies. Standard econometric issues are relevant here
Step 7	Gather summary data for the policy site (Z_{Pj}). The meta-regression analysis model has several associated independent variables. Gather summary data on the policy site for as many of the variables in the model as possible
Step 8	Predict the policy site summary statistics (V_{Tj}) from the meta-regression model (Vf_S) by multiplying the summary statistics reflecting the policy site (Q_P, Z_P, M_P) by the regression coefficients ($Vf_S(Q_{S\|P}, Z_{S\|P}, M_{S\|P})$) in the transfer function. This results in a tailored estimate for the policy site (V_{Tj})
Step 9	Aggregate the tailored estimate to the policy site context by multiplying it by the total number of units, providing a total value estimate for the good or service at the policy site

Adapted from Stanley (2001)

Table 11.8 Summary statistics for whitewater rafting/kayaking metadata

Variable	Description	Mean values	
		Full data	20% trimmed
South	1 = Southern Census Region; 0 = otherwise[a]	0.269	0.250
West	1 = Western Census Region; 0 = otherwise[a]	0.654	0.625
Site quality	1 = site quality is rated high by author; 0 = otherwise	0.673	0.625
Sample frame	1 = sample is drawn from onsite visitors; 0 = otherwise	0.519	0.594
Valuation method	1 = travel cost model; 0 = otherwise	0.519	0.406
Trip type	1 = private trip; 0 = otherwise	0.558	0.500
Average flow	Average river flow in cubic feet per second (cfs)	14,204	13,975
Change in elevation	Elevation change: Source to mouth of river in miles	6,576	6,374
River length	Length of river in miles	606	578
Wild and scenic	1 = portion of river is designated wild and scenic; 0 = otherwise	0.500	0.438
No. of observations	Number of estimates of recreation value	52	32

[a]Omitted category is Northeastern Census Region (plus no observations in Midwestern Census Region)

from researchers who work closely together. There is also the potential for autocorrelation due to learning effects and improvements in methodology over time.

The steps to conducting a meta-regression analysis (Table 11.7) are adapted from Stanley (2001). An application of meta-regression analysis is illustrated by evaluating the studies and estimates included in Table 11.2 and the reduced set in Table 11.3. Again, the policy target is to derive an estimate of private whitewater rafting or kayaking on the Klamath River.

Table 11.8 provides variable descriptions and summary statistics for the full and 20% trimmed metadata. Specific characteristics gleaned from each study included the census region of the study, the quality of the site as stated by the authors of each study, the sample frame and valuation method used by the authors, and the type of recreation trip (i.e., private versus commercially guided trips). Information for each study location was augmented with proxy measures for river quality and characteristics, including the average river flow, overall change in elevation of the river from its source to its mouth, the overall length of each river, and whether some portion of the river has been federally designated as a national wild and scenic river. While these proxies for whitewater qualities are crude, they are systematically related to variations in value estimates reported in the literature. Better proxies of river quality might be obtained through the use of geographic information systems data (e.g., see Ghermandi et al., 2010), which may reduce the inherent measurement error when deriving proxy measures through data augmentation.

Next a regression analysis is conducted where the valuation estimates adjusted for units and inflation are the dependent variable and the variables described in Table 11.8 are the independent variables. The goal of the regression model is to explain as much of the variation in the dependent variable across the studies as possible using the independent variables. Correcting the model for common statistical issues (e.g., multicollinearity and heteroskedasticity) is relevant here (Nelson and Kennedy 2009). After testing for and affirming a normal distribution for the dependent variable, an ordinary least squares model is estimated. Several of the independent variables cannot be included in the regression because insufficient information is provided by individual studies. For example, most of the studies did not report any summary statistics regarding the characteristics of their sample population, such as mean income, age, education, etc. These variables may be important to explaining some of the variation in the value estimates, but they cannot be tested when information on them is not provided in the original studies.

Table 11.9 provides the meta-regression analysis results for the full metadata and the 20% trimmed metadata. Also included in the table is an example application of these meta-regressions as benefit function transfer, which will be discussed below. For now, focus on the two columns reporting coefficient estimates. The dependent variable is the natural log of the value per person, per day, as reported by each study. Overall, these simple meta-regressions fit the data very well, with R^2 values of 0.65 and 0.79 for the full metadata and 20% trimmed metadata samples, respectively. The regression results show that rivers studied in the Southern Census Region have statistically higher value estimates than rivers studied elsewhere; average river flow and overall change in elevation for each river are statistically and positively related to value estimates; and river length is statistically and negatively related to value estimates for the full metadata meta-regression analysis. For the 20% trimmed metadata, the regression results are consistent in the direction of measured effects (i.e., positive or negative) with the full metadata regression (the exception is valuation method, which is insignificant in both models). However, the statistical significance of some of the estimated coefficients has changed. Up to this point, the meta-regression analyses provided statistical summaries or quantitative reviews of the literature. Now the meta-analysis regressions are used as benefit transfer functions.[6]

The meta-regression analysis transfer function is defined as

$$Vf_S\left(Q_{S|Pj}, Z_{S|Pj}, M_{S|Pj}\right) = V_{Tj} + \varepsilon = V_{Pj}. \qquad (11.6)$$

Equation (11.6) states that the value for policy site j (V_{Pj}) is a function of data included in or distinguishable from each study site i. The other variables can be quantity/quality variables (Q); socio-demographic variables (e.g., income, age, and

[6]The potential use of meta-regression analysis in defining benefit transfer functions is like the holy grail of benefit transfer: developing a function that can be used to estimate different types of values for different policy contexts. That is, even in conditions where no point estimates or demand functions are reported in the literature, a meta-regression analysis function may be able to provide such estimates or functions.

Table 11.9 Meta-regression analysis and function predictions, whitewater rafting/kayaking on the klamath river

Variable	Full data MRA[a]			20% trimmed data MRA[b]		
	Coefficient	Policy value[c]	Increment[d]	Coefficient	Policy value[c]	Increment[d]
Constant	3.30478*	1	3.30	3.52250*	1	3.52
South	1.23337*	0	0	1.17058*	0	0
West	−1.05715	1	−1.06	−0.22583	1	−0.22
Site quality	0.57336	1	0.57	0.67515*	1	0.68
Sample frame	0.77846	0.52	0.40	0.48632	0.59	0.29
Valuation method	−0.86976	0.52	−0.45	0.08210	0.41	0.03
Trip type	−0.59010	1	−0.59	−0.33194*	1	−0.33
Average flow	0.00003*	17010	0.22	0.00001*	17010	0.09
Change in elevation	0.00057*	4090	3.03	0.00018	4090	0.98
River length	−0.00317*	263	−0.68	−0.00091	263	−0.20
Wild and scenic	−1.24168	1	−1.24	−0.80212*	1	−0.80
Root MSE[e]	0.72056			0.40129		
R^2	0.6504			0.7866		
Predicted value[f]			$25.94			$53.94
95% confidence interval[g]			$17-40			$36-82

*Significant at the 0.10 significance level. Dependent variable is natural log of consumer surplus per person, per day (2013 $)
[a]Ordinary least squares cluster robust regressions where clusters are defined by individual studies (No. clusters = 14)
[b]Ordinary least squares cluster robust regressions where clusters are defined by individual studies (No. clusters = 10)
[c]Policy values are set to best match policy site conditions except for methodology variables, which are set at their mean values for the metadata
[d]Incremental effects are coefficients × policy values. The sum of increments = natural log of consumer surplus per person, per day (2013 $)
[e]Root mean square error (MSE) = $\sqrt{\sigma^2}$
[f]Predicted value calculated as exp(σ^2/2) * exp(predicted natural log of consumer surplus per person per day)
[g]95% confidence intervals calculated as predicted value ± 1.96 + se (θ) [se(θ) is standard error of the fitted regression]

education) and site characteristics (e.g., presence of water, geographic location, and land type; *Z*); and methodological variables (e.g., valuation method, modeling format, and functional form; *M*) for each study (*i*). The application of this model to benefit transfer is similar to adjusting the benefit function discussed in the previous section. Value estimates tailored to a policy site may be obtained by adjusting the meta-regression analysis function to specific characteristics of that site.

To recap previous benefit transfer applications, a literature search was conducted that identified two documents reporting value estimates seemingly specific to the policy site. However, an analyst may be concerned about the age of these studies and/or the implicit modeling assumptions used by the primary study authors. This led to a broader literature search on whitewater rafting or kayaking in the United States. Expanding on the literature search criteria resulted in 14 studies reporting a total of 52 estimates. An average value from the literature could be calculated. The effect of very low or very high estimates on calculated average values is explored through trimming the tails of the distribution from this literature. Now, meta-regression analysis functions are used that control for systematic relationships among the data to predict estimates of value for the policy context.

Table 11.9 illustrates how the meta-regression functions can be used to predict value estimates. The variables are set to levels that match the policy site (see Policy Value columns in Table 11.9), including the partial effects of the region, site quality, trip type, and wild and scenic river status by setting these parameter values at 1. The partial effect of the South Census Region is negated in the model by setting its parameter value to 0. There is no a priori reason to judge the sample frame or valuation method, so these parameter values are set at their mean values in each metadata sample (this approach includes the average partial effect of methodology variables as included in the metadata). The partial effects of river flow, change in elevation, and river length are set to match the policy site's characteristics. The predicted value for whitewater rafting or kayaking on the Klamath River is $26 per person, per day, with a 95% confidence interval of $17 to $40 for the full metadata function. The 20% trimmed metadata function results in a prediction of $54 per person, per day, with a 95% confidence interval of $36 to $82. Based on overlapping confidence intervals, these two predictions are not statistically different from each other; however, the overlap is modest and the absolute magnitudes of the average predicted values would lead to different aggregate measures of recreation benefits.

Just as an analyst may be concerned that the most similar site point estimate transfer values are too low relative to the rest of the empirical literature, the average value transfers for the entire data, regional data, or trimmed data may be too large (Tables 11.2 and 11.3). The meta-regression benefit transfer functions' predictions may be relatively more defensible given they not only rely on the broader valuation literature but enable the adjustment of values to the policy site context based on measurable differences among study sites. The prediction from the full metadata regression prediction has a confidence interval that includes estimates from two of the most similar studies, while the trimmed metadata regression prediction is more than the most similar study's estimates. Further augmenting the metadata may lead to better (i.e., more defensible) predictions, although the need for precise, valid measures may only be derived through conducting an original study, that is, if the analyst has the resources available to make such a choice. If not, then benefit transfer may be the best and only option for deriving value estimates.

11.3.2.3 Structural Benefit Function Transfers

One of the limitations of the benefit transfer methods discussed in this chapter is the general lack of a micro-level theoretical foundation that clearly links consumer utility functions to the benefit transfer process (Johnston and Rosenberger 2010). This formal modeling of the utility functions for benefit transfer applies to both value and function transfers, which were previously discussed.

Bergstrom and Taylor (2006) tackle this issue by distinguishing between strong structural utility theoretic models, weak structural utility theoretic models, and nonstructural utility theoretic models. Strong models explicitly derive a benefit transfer function or meta-analysis equation from a utility function. At the other end of the spectrum, nonstructural models do not attempt to explicitly link the benefit transfer function or meta-analysis to an explicit utility function. Rather, they merely attempt to specify a benefit transfer function or meta-analysis that would be consistent with economic theory. As Bergstrom and Taylor (2006) note, strong structural utility theoretical models are preferred, and weak structural utility models are acceptable on theoretical grounds. They state that nonstructural utility theoretical models are not suggested for performing meta-analysis benefit transfer. Obviously, this recommendation must be balanced with whether time and budget are available to assemble data needed for a strong structural benefit transfer or whether existing "off-the-shelf," weak structural utility theoretic-based meta-analyses will have to be used or not. If these weak structural meta-analyses models are used due to expediency, this limitation should be pointed out.

Smith et al. (2002) proposed an alternative benefit transfer method that they call structural benefit transfers or preference calibration transfers. In structural benefit transfers, the analyst specifies a utility function that describes an individual's choices over a set of market and nonmarket goods or services, assuming a standard budget-constrained utility maximization problem (Smith et al. 2006). An analytical expression is derived that links available benefit measures to the assumed utility function, which defines the theoretical foundation for transfers. Calibration of benefit measures and other pertinent information is conducted to ensure the consistency of measures across each study. While these models impose theoretical consistency on the use of prior information, they are also limited in that they require a strong a priori assumption regarding the underlying structural model. Furthermore, the structural benefit transfer method is more complex than the weak structural utility theoretic models discussed previously, which may be one reason it has not been widely adopted or applied (Johnston and Rosenberger 2010). Nonetheless, there is wide agreement that strong structural utility theoretic models have many potential benefits over weak structural utility theoretic models (McConnell 1992; Boyle et al. 1994; Bergstrom and Taylor 2006).

Table 11.10 Summary of absolute percentage transfer error (|PTE|) by research studies[a]

Transfer type	Median |PTE|	Mean |PTE|	Std. error of mean |PTE|	*N*
Value	45	140	10.6	1,792
Function	36	65	4.0	756

[a]See http://recvaluation.forestry.oregonstate.edu/sites/default/files/PTE_Summary.pdf for a table listing individual studies, percentage transfer errors, and other pertinent information on specific benefit transfer error studies

11.4 Accuracy of Benefit Transfers: How Good Are Benefit Transfers?

Assessing the precision and accuracy of a particular benefit transfer is usually impossible because the actual value for a policy site (V_{Pj}) is unknown; otherwise, there would be no need for benefit transfer. If the best approximation of the actual value for a policy site is not known, then how does the analyst know how close the benefit transfer (V_{Tj}) is to the actual value (V_{Pj})? It is like playing pin the tail on the donkey without the donkey. How can one know how close he or she is to the target when no target exists? Therefore, in order to assess the validity and reliability of benefit transfer, the target's value must be known. Validity tests of benefit transfer include access to some original research; that is, where $V_S = V_P$ when $i = j$. Based on outcomes from benefit transfer validity and reliability studies, indicators emerge as to when and why some transfers are better than others (i.e., when ε in $V_{Tj} + \varepsilon = V_{Pj}$ is small), which are discussed later in this chapter.

Several studies have evaluated the validity and size of transfer error ε associated with benefit transfers in varying contexts (Bergstrom and DeCivita 1999; Brouwer and Spaninks 1999; Morrison and Bergland 2006; Rosenberger and Stanley 2006; Johnston and Rosenberger 2010; Rosenberger 2015). The magnitude of acceptable transfer error may vary based on the specific context for the transfer. For example, lower transfer errors (i.e., more precision) may be needed for the calculation of compensatory amounts in negotiated settlements and litigation than situations requiring broad benefit-cost analyses as information gathering or screening of projects and policies (Navrud and Pruckner 1997).

There are generally two categories of benefit transfer errors: measurement error and generalization error (Rosenberger and Stanley 2006). Measurement errors are associated with the original research that provides value estimates used in benefit transfer. While these errors are embedded in the information to be transferred, an analyst may minimize these errors by evaluating the quality of original research—a transfer can only be as good as the information on which it relies. Generalization, or transfer, errors are errors associated with the transfer process itself, including poor correspondence between the study and policy sites and the type of transfer method employed. Matching the contexts of the study and policy sites helps minimize transfer error (Boyle et al. 2009, 2010).

Table 11.10 provides a summary of the various studies that directly evaluated benefit transfer accuracy. In particular, these studies measured percentage transfer error (PTE) as follows:

$$PTE = \left[\left(\left(V_{Tj} - V_{Pj}\right)/V_{Pj}\right)\right] \times 100, \quad (11.7)$$

where V_{Tj} is the transferred estimate and V_{Pj} is the known policy site estimate. Summary statistics reported for each benefit transfer study include the number, median, mean, and range of absolute values of PTE (|PTE|). Each study is further classified by resource type, primary valuation method, and benefit transfer category (i.e., value or function transfer). This information will help the analyst identify specific types of benefit transfer tests he or she may want to investigate further given the context of the analyst's own benefit transfer.

There are 38 studies behind the summary statistics reported in Table 11.10, with almost half of them ($N = 18$) evaluating value and function transfers within the same context. There are 1,792 estimates of PTE for value transfers and 756 estimates of PTE for function transfers. Value transfers have a higher range in possible PTE estimates than function transfers, although both ranges are large. Value transfers have a mean |PTE| of 140% and median of 45%. Function transfers have a mean |PTE| of 65% and a median of 36%. The differences in mean and median |PTE| for value versus function transfers are statistically significant at the 99% confidence level, supporting the conclusion that function transfers outperform value transfers in general (Johnston and Rosenberger 2010; Kaul et al. 2013; Rosenberger 2015).

Based on median |PTE|, benefit transfers generally perform well, although if improperly done, they can result in substantial transfer error. It is often suggested that following some best practice guidelines for benefit transfer will reduce transfer error, providing the analyst with confidence in specific applications (Boyle et al. 2009, 2010; Johnston and Rosenberger 2010). A quantitative assessment of factors associated with varying levels of PTE is provided by Kaul et al. (2013) and Rosenberger (2015), suggesting a few patterns in the benefit transfer literature. Errors are generally found to be smaller in cases where sites and populations are most similar (Rosenberger and Phipps 2007). Studies that illustrate the importance of site correspondence include Loomis (1992), Piper and Martin (2001), Rosenberger and Loomis (2000), VandenBerg et al. (2001), Barton (2002), Morrison et al. (2002), Morrison and Bennett (2004, 2006), Johnston (2007), and Colombo and Hanley (2008).

Function transfers are shown to generally be better than value transfers. Intrastudy comparisons of value versus function transfers show that function transfers result in a lower mean and median |PTE| than value transfers the majority of the time[7] (e.g., Loomis 1992; Parsons and Kealy 1994; Bergland et al. 2002; Bowker et al. 1997; Kirchhoff et al. 1997; VandenBerg et al. 2001; Groothius 2005; Kristofersson and Navrud 2007; Matthews et al. 2009; Boyle et al. 2010;

[7]The range of PTE estimates from the literature are provided in an appendix located at http://recvaluation.forestry.oregonstate.edu/sites/default/files/PTE_Summary.pdf.

Rosenberger 2015). In some applications, given both the study site and policy site measures are provided in the same original research, many estimates of value are compared—not because they should be, but because enough information is provided to do so. These naïve transfers illustrate the risk of high transfer errors if inappropriate transfers are conducted. For example, Lindhjem and Navrud (2008) compare several types of transfers and analysts' assumptions. Their results show that PTE magnitude and range are reduced when screening for best fit or using a meta-analysis function to predict policy site values. And finally, interpretations of PTE as validity indicators are weak because study site values themselves are estimated with error, leaving real transfer errors largely unknown (Rosenberger and Stanley 2006; Boyle et al. 2010).

The literature reports other types of validity tests, including a difference in means test and a difference in model coefficients test (Rosenberger 2015). These are tests wherein value and model coefficient estimates and their standard errors are compared between study sites and policy site applications. In general, these tests reject the null hypotheses that the means and coefficients are equal the majority of the time, and they have a weak positive correlation with PTE measures. While these particular validity tests suggest benefit transfers are not valid, they often fail to recognize the context of benefit transfers and acceptable levels of accuracy. Furthermore, these validity tests show a counterintuitive result in that less efficient statistical estimates (i.e., larger standard errors of estimates) have a greater probability of failing to reject equality compared with more efficient estimates (i.e., smaller standard errors of estimates), implying greater transferability (Kristofersson and Navrud 2005). Nonetheless, standard hypothesis tests remain the norm in the benefit transfer literature (Lindhjem and Navrud 2008).

Alternative types of validity tests have been proposed, but not widely adopted (Lerman 1981; Desvousges et al. 1998; Spash and Vatn 2006; Lindhjem and Navrud 2008). For example, there is literature that applies equivalence testing within benefit transfer (Muthke and Holm-Mueller 2004; Kristofersson and Navrud 2005; Hanley et al. 2006a; Johnston 2007; Johnston and Duke 2008). Equivalence testing changes the burden of proof in traditional hypothesis testing by reversing the null and alternative hypotheses (i.e., estimates are assumed different unless tests show the difference is smaller than a specified tolerance limit and probability value). In benefit transfer applications, the tolerance limit is specified as the maximum acceptable level of transfer error for which transfer and policy estimates are considered equivalent (e.g., Kristofersson and Navrud, 2007, and Johnston and Duke, 2008, use tolerance limits of 40%, while Baskaran et al., 2010, use 50 and 80%). These tolerance limits may be set based on the context of the benefit transfer exercises, as noted previously (Navrud and Pruckner 1997).

11.5 Criteria for Choosing Among Benefit Transfer Approaches

An evaluation of published benefit transfer studies suggests that there is no single best method. How does the analyst choose the method that is the best fit for his or her application? Ultimately, the best choice might be to minimize expected transfer error. While the choices may not be straightforward or simple, five criteria are identified that are useful for guiding these decisions. A point estimate transfer may be preferred when the available study site estimates closely match the policy site on (1) the good being valued, including quantity and quality, activity type, resource attributes (e.g., water clarity), or species of interest; (2) the geographic area being evaluated; (3) the affected population and its characteristics; (4) the welfare measure (e.g., property rights assignments, WTP); and (5) the valuation methods used in the study site application are conceptually, theoretically, and empirically sound.

The analyst may not be able to match all five criteria between available studies and defined policy needs. As the number of matches dwindles, the analyst may be best served to move to other methods that rely on functional relationships among the values and underlying data. If a valuation function is available in the set of candidate studies, then a function transfer approach may be more accurate than point estimate transfers (at least based on the summary of validity results found in Table 11.10). In part, the advantage of valuation function transfers is when there is not a good match between the study site and policy site on some of the criteria, but information is available that enables adjustments to be made.

However, there may be times when a valuation function cannot be found that matches some of the five factors, and the additional information needed for adjusting estimates is not available. In this case, if several studies are available that collectively match the five criteria, then an average value or some other measure of central tendency might be transferred with greater defensibility than relying on a valuation function from any one of the studies.

If at this point the analyst is left with only two to three studies that reasonably match his or her policy needs, then two other options are available. The most defensible choice would be to consider developing a meta-analysis regression transfer function, assuming the literature is robust enough for statistical modeling. As noted previously, meta-regression functions provide a means for the analyst to capture and control for many of the differences between the policy site and the available literature. Any resulting benefit estimates should be treated as a “generic value” that is primarily indicative of the range of likely value estimates.

Another, less defensible, option is to use a “back-of-the-envelope” method based on transferring an administratively approved value. Choice of this method is often based on the analyst not having training or experience in nonmarket valuation. While this method is used by agencies and other groups, its use is not recommended until all other options have been exhausted.

In some circumstances, there may be no clear “superior” approach for conducting the benefit transfer. In other words, no one method can, even collectively, satisfy all five of the factors. In this case, the analyst should evaluate all potential methods, given information constraints, and apply the ones that seem plausible in order to provide the decision-maker with a range of estimates that reflect the uncertainty in benefit transfer estimates. A range of estimates of benefits may be sufficient for the purpose of some economic analysis, and it avoids providing the decision-maker with a false sense of precision that providing a single estimate might convey.

At what point might the analyst simply indicate that no defensible estimate of value can be derived from benefit transfer? It depends on the purpose of the benefit transfer value. If the benefit transfer value is merely being included so the analysis acknowledges that there are economic benefits received from the nonmarketed resource, then even unit day values may make this point better than omission of any value at all. However, if the benefit-cost decision is likely to hinge on the values calculated from one of these weaker benefit transfer methods, it may be necessary for the analyst to present the limited valuation evidence to the decision-maker, along with a recommendation that even a simple original primary valuation study is likely to yield more accurate results than reliance on a mismatched benefit transfer estimate (possibly guided by the decision method presented in Allen and Loomis, 2008). Ultimately, it is up to the decision-makers to make the call because they will have to defend their policy or project decision.

11.6 Conclusions

This chapter was intended to expose the reader to the world of benefit transfer. The method of benefit transfer is described along with example applications. The reader's understanding should now be sufficient to critique benefit transfer or even conduct his or her own benefit transfer.

In the end, the analyst must decide whether he or she can perform a defensible benefit transfer that will improve decision-making by an approximation of the value of some nonmarket resource (e.g., recreation, water quality, etc.) versus decision-making with no information on the economic values of affected nonmarket resources. When there is uncertainty about which benefit transfer method to apply or what assumptions must be made to apply a particular benefit transfer method, the analyst should present a range of value estimates. In some cases, such a range of economic values of these nonmarket resources may be sufficient to determine whether this range is above or below the cost of a particular policy or project. In other cases, providing decision-makers with a rough idea of the magnitude of nonmarket values helps change their perceptions of the relative values of natural resources or ecosystem services flowing from their area (Ervin et al. 2012). Timely valuation information is often more useful for decision-making than no estimate whatsoever, but the analyst must guard against the tendency to go out on the "benefit transfer limb" of feeling compelled to provide some estimate, regardless of its accuracy. "Incredible" estimates will undermine the overall credibility of benefit transfer in particular and nonmarket valuation in general.

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