Incorporating spatial heterogeneity in value transfer functions

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Introduction and problem statement

With this discussion note we aim to identify ways to solve one of the main problems with contemporary value transfer functions. Although value transfer is used extensively in practice, relatively little published evidence exists about its validity and reliability. The central problem identified is that most value transfer studies show that existing value transfer functions produce large transfer errors (see, e.g., Brouwer and Bateman, 2005; Rosenberger and Loomis, 2003; Van den Berg, Poe and Powell, 2001). Stated differently, the value predicted by a value transfer exercise can largely over- or understate the true value. Our central hypothesis is that this is in large part due to the fact that most functions do not contain spatially specific information. Stated differently, value transfer functions that do not incorporate crucial information on the context of the specific study will produce prediction estimates that are substantially off the mark. This note contains a discussion of ways to improve existing value functions and a concrete research proposal. Before doing so we discuss value transfer in the next section, while Section 3 is dedicated to meta-analysis. Our research proposal on incorporating spatial complexity in value functions is discussed in Section 4. Section 5 identifies how we will test the added value of spatially explicit value functions, and in which of the exemplars we aim to apply these functions. In Section 6 we discuss how we will ensure perennity of the efforts of our study.

Value transfer

In the literature, value transfer is commonly defined as the transfer of monetary environmental values that are estimated at one site (study site) to another site (policy site). The study site refers to the site where the original study took place, while the policy site is a new site where information is needed about the monetary value of similar costs and/or benefits. The most important reason for using previous research results in new policy contexts is that it saves a lot of time and money. Transfer studies are essential for practical policy analysis because policy analysts usually do not have the time and resources of designing and implementing an original study (e.g., Pearce et al., 2006; TEEB, 2011). Value function transfer differs from value transfer in that a value function is used to calculate the value of a good or service in a new area, rather than that a constant unit value is derived from the literature.

The methods used for value transfer can be roughly divided into two types (Navrud and Ready, 2007). The simplest approach is to attempt to find study sites which are more or less similar to the policy site, and transfer mean values from the former to the latter (e.g., Muthke and Holm-Mueller, 2004). Such mean value transfers are frequently used in practical decision making, and are crucially dependent upon differences between transfer sites. A problem with this approach is that all sites are at least to some extent dissimilar. Because of this problem value function transfer approaches have been developed, in which statistical techniques are used to estimate a value function from study site data. This function is subsequently used to predict new values for policy sites. This is achieved by assuming that the underlying utility relationship embodied in the parameters of the estimated model applies not only to individuals at the study sites but also to those at policy sites. Usually, these parameters are kept constant, while the values of the explanatory variables to which they apply are allowed to vary in line with the conditions at the policy site. In those cases where results are used from studies carried out years ago, an important question obviously is to what extent preferences and parameters have changed (Brouwer, 2006).

Pearce et al. (1994) argue that value function transfers allows for greater control over differences across sites, implying they should in principle yield lower transfer errors than simple mean value transfers. However, empirical evidence on this issue is mixed (e.g., Bergland et al., 2002; Barton, 2002; Ready et al., 2004). This is partly due to the lack of a systematic assessment of a set of (theoretically driven) baseline conditions needed to be in place for valid and robust value transfer. In a cross-country comparison, Brouwer and Bateman (2005) show that a simple unadjusted unit value transfer works best for similar case study sites, while errors generated by simple mean value transfer are considerably larger than those arising from function transfer across dissimilar case study sites. As expected, if conditions are not the same across study and policy sites, some degree of adjustment helps reducing the error.

Meta-analysis

In principle, any empirical study can be used for value or value function transfer. Examples of choice experiments that were used for value transfer are Morrison et al. (2002), Bueren and Bennet (2004), Morrison and Bennet (2004), Jiang et al. (2005), Colombo et al. (2007), Colombo and Hanley (2008), and Martin-Ortega et al. (2012). Generally, however, value functions resulting from meta-analysis studies are used. Meta-analysis is a method with which a researcher can summarise, synthesise and analyse the available empirical evidence on a certain topic, e.g., environmental value estimates from studies that employ a certain economic valuation method (e.g., contingent valuation, choice experiment, hedonic pricing, travel cost). The procedure of doing a meta-analysis is relatively straightforward. First, the available empirical evidence on the topic of interest is gathered by using relevant predefined keywords in standard available search engines (Google Scholar, Scopus, Web of Science, etc.). Second, the outcomes of studies and their the characteristics are coded and put into a database. Finally, the data are analysed using more or less advanced statistical techniques, such as regression analysis, and insights into the relevant sources of variation in ecosystem service values are obtained. Important empirical applications of meta-analysis in the field of ecosystem service valuation are Bateman and Jones (2003), Boyle et al. (1994), Brander and Koetse (2011), Brander et al. (2006), Brouwer et al. (1999), Smith and Huang (1995), Van Houtven et al. (2007), Woodward and Wui (2001).

A clear advantage of meta-analysis is that pooling the estimates from various studies may provide a preferable estimate of value, i.e., an estimate with a smaller confidence interval. Also the non-systematic and study-specific effects on value estimates are averaged out in a meta-analysis. Another advantage is that a meta-analysis provides quantitative insight into which factors are relevant in explaining the variation in the available empirical evidence. Since the studies used in the meta-analysis are as a rule based on different data-sets from multiple countries and different time frames, meta-analysis generally provides greater possibilities for generalisation than a single case study does. For our purposes it is especially relevant that the development of Geographical Information Systems (GIS) allows for gathering spatially specific case-study data. By including these data in the model specification more spatially explicit predictions and generalisations can be made.

Research proposal and design

While value transfer may provide a quick and cheap alternative to original valuation research, some conditions must be met if it is to provide reliable results (see Desvousges et al., 1992, for an overview). Above all, the local circumstances and conditions in the new decision-making context need to be closely related to the ones prevailing in the original research. The risk of obtaining misleading results may be controlled and reduced by integrating more explanatory variables into the transfer. We follow up this suggestion by including in the meta-analysis database the spatial characteristics of study areas. These characteristics are obtained from external resources, generally using geographical information systems (GIS).

To our knowledge the study by Perino et al. (2014) is the only study that systematically accounts for spatial heterogeneity in value transfer. In a meta-analysis of urban greenspace values in the UK they incorporate spatial information on income, population density and size of and distance to the greenspace. The resulting spatially specific value function is used to derive greenspace values per household in various major UK cities. However, the study does not explicitly test the added value of including spatial heterogeneity for the accuracy of value transfer.

Spatially explicit variables

Our goals are similar to those of the Perino et al. (2014) study. A first goal is to collect existing and build new meta-analyses databases, and incorporate spatially explicit information in these databases in order to arrive at spatially specific value transfer functions. The spatial variables we aim to include in these meta-analyses are:

1. Income of population in study area;
2. Population density of study area;
3. Distance of population to good or service of study (distance decay);
4. Quantity/size of good or service of study;
5. Overall scarcity and supply of good or service of study;
6. Quality of good or service of study.

When the good or service under investigation is a normal good, income will have a positive effect on its value. Regions with higher income are expected to put a higher value on, for example, water quality and forests. Population density is often shown to be relevant as a measure of both crowdedness and scarcity of supply of environmental goods and their amenities (e.g., Brander and Koetse, 2011). Distance to and quantity or size of the good or service of study have also been shown to be important for values obtained (e.g., Perino et al., 2014; Brander and Koetse, 2011). The larger the distance to the good, the lower its value. The larger the quantity or size of the good, the higher its value, although with diminishing marginal returns (e.g., Koetse et al., 2014). Overall supply of the good or service under study is an important indicator of scarcity and substitution potential. For example, when a region has a limited supply of forests or water for recreation, forest and water values are expected to be higher because the good is scarce and there are no or little substitutes. Finally, quality of the good or service will increase its value.

All these variables are likely relevant in explaining the variation in study outcomes, and therefore are crucial elements of a value transfer function. Moreover, these variables will vary between cities and regions, so not accounting for this variation in a value transfer exercise may lead to large prediction (value transfer) errors.

Meta-analysis databases

We intend to extend and/or develop the following meta-analysis databases:

- Meta-analysis database of water values from TC and CV studies;
- Meta-analysis database of forest values from TC and CV studies.

The databases on water values already exists, but will be updated both in terms of studies and in terms of including the spatially explicit variables. The database on forest values is in development, and will make use of existing meta-analysis studies on forest values (see Table 1). We expect to finalise these two databases in 2015.

Reference	Ecosystem	Ecosystem service
Barrio and Loureiro (2010)	Forests	All
Chiabai et al. (2011)	Forests	Recreation, non-use values
Lindhjem (2007)	Forests	Non-timber benefits
Ojea et al. (2010)	Forests	Provisioning, regulating, cultural
Zandersen and Tol (2009)	Forests	Recreation

Table 1. Existing meta-analyses of forest values

Although it is possible to include all of the spatially specific variables in both databases in principle, in some cases there may/will be constraints in terms of data availability. For example, water quality is documented for many areas across the globe, but quality of forests is not. This basically implies that forest quality cannot be incorporated, and that differences in quality will be subsumed in region-specific dummy variables.

Testing and applications

Testing added value of spatially explicit value functions

There are various ways in which transfer errors can be derived and value function accuracy can be tested. For example, Barton and Mourato (2003) implement very similar contingent valuation surveys in Portugal and Costa Rica, and use the value function for Portugal to predict values for Costa Rica (for similar approaches see also Barton, 2002; Bergland et al., 1995; Brouwer and Bateman, 2005a). A related method is used by Parsons and Kealy (1994), who divide a CV dataset on lake recreation in Wisconsin into two separate subsamples. The value function for one subsample is subsequently used to predict values for the other subsample, and predictions are compared to actual values. The approach by Brouwer and Bateman (2005b) is similar in that they conduct identical CV studies, but they transfer between different time periods within the same site rather than between different sites at a single point in time, thereby testing for temporal rather than geographical stability. Similar split-sample approaches but with choice experiments as the valuation method are used by, among others, Morrison et al. (2002) and Martin-Ortega et al. (2012).

Within the context of meta-analysis the approaches discussed above are not viable, and we will have to rely on other methods. Specifically, in our study we apply the jack-knifing method (see, e.g., Brander et al., 2006; Lindhjem and Navrud, 2008). This method consists of the following steps:

1. take one study out of the database;
2. estimate the value function;
3. use the value function to predict the value for the excluded study
4. measure the prediction error;
5. repeat the procedure for each study;
6. calculate the average prediction error and plot the error distribution.

In order to assess the differences in prediction accuracy we compare results for the value function *with* spatially explicit parameters with those for the value function *without* spatially explicit parameters. Not only does this allow us to assess the differences in the mean transfer error and the transfer error distributions, it also allows us to identify which those studies for which the transfer error is reduced the most. This may shed more light on the circumstances in which adding spatially explicit information has them most added value.

An alternative but related approach is to use the value functions with and without spatial parameters for predicting values from studies published after the study is conducted. In the section on perennity of the project we discuss this issue in more detail.

Applying spatially explicit value functions in exemplars

Value transfer at small geographical scales may lead to larger transfer errors than at larger geographical scales. The reason is that local sites situations generally have very specific contexts that can be incorporated in the value function to a limited extent, also in the case of spatially explicit value functions. Although some of these context variables can still be included through the space- and time-specific elements of the value transfer function, some of them cannot or only to a very crude extent. These problems are reduced when applying value transfer at larger scales, because the effects of specific contexts at the local scale are averaged out. The accompanying hypothesis is therefore that value transfer errors are lower at larger geographical scales. Although value transfer can be applied in various exemplars with different geographical scales, measuring the magnitude of transfer errors in each case may prove difficult, because it would necessitate exemplar specific valuation studies. Although this is possible in principle, it is likely outside the scope of the project and would require very specific and similar (if not identical) research designs in exemplar-specific valuation studies. Still, it is a good idea to apply value transfer in exemplars of different geographical scales. Moreover, our meta-analysis databases deal with values of water, forest and urban open space, while various exemplars deal with other or a broader set of ecosystem service values. Potentially interesting exemplars, at first sight, are therefore:

- Balearic Islands Spain (local level);
- Scottish exemplar (local and national level);
- European exemplar (regional level);
- Global exemplar (global level).

In these exemplars we aim to assess and compare value transfer results with and without spatially explicit variables. Even though counterfactual 'true' values for these exemplars are lacking, this comparison is still useful because it may show the impact of incorporating spatial information in new study sites.

Perennity

In this note we propose to build new and expand existing meta-analysis databases, with a focus on incorporating spatially specific information. With this we aim at deriving improved spatially specific value transfer functions, which can be tested and applied in various exemplars. Next to the more or less direct outputs from this study, we also aim to keep these databases up to date. More specifically, our goal is to (bi)annually keep track of new and relevant studies, include the results in the existing databases, and update the value functions. This has three distinct advantages. First, it will ensure that we always have an up to date overview of relevant studies, that our knowledge base expands continuously, and that value transfer functions are continuously improved because more information is included. Second, we can work towards a database that covers the entire globe, implying more accurate value transfer functions and more detailed insights and predictions for every region in the world. Moreover, we may be able to tackle issues related to scarcity more thoroughly as time progresses. Stated differently, more data implies that we have more variation between studies in terms of supply and scarcity. In doing so we may also be able to better deal with dynamics, i.e., we may be able to model a demand curve that reflects changing marginal values due to changing preferences, changing conditions and changes in supply over time. Third, this approach implies we can test our value functions on out-of sample study sites, and assess whether the value transfer accuracy improves over time by including more and more information.

When the databases are finished we intend to publish their meta-data (i.e., not the databases themselves, as we intend to expand them and publish with them) and the value transfer functions on the IVM-VU website. After each update of the databases we will also update the meta-data and value transfer functions on the website.

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