Spatial effects in economic valuation of river basins using stated preference techniques

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Abstract

Many environmental valuation studies essentially involve spatial choices. In these spatial choices, both respondents and alternatives are located in space and their relationship determines decision outcomes. Surprisingly, only few stated preference (SP) studies account for these spatial attributes, of which distance and substitution are the most obvious and relevant, also for non-use values. This paper discuss ways in which different disciplines such as spatial economics, social and economic geography, environmental psychology and ecology address spatial attributes of environmental valuation cases in decision-making behaviour, which will allow for a better understanding of spatial aspects of WTP. This overview results in recommendations to improve SP studies and account for the spatial characteristics, both for study design as well as statistical analysis. The most important recommendations are to account for perceptions and hierarchies in spatial choices, account for locational differences and distances in the sampling strategy, and account for substitutability and interaction between environmental sites due to spatial site-characteristics and distribution of substitute and complementary sites over the study area.

1.0 Introduction

Many environmental valuation studies essentially involve spatial choices. In these spatial choices, both respondents and alternatives are located in space and their relationship determines decision outcomes. Surprisingly, only few stated preference (SP) studies account for these spatial attributes, of which distance and substitution are the most obvious and relevant. If at all, SP studies have addressed spatial influences on WTP through preferences and choice behaviour by looking at direct distance-decay effects. Since spatial choices are usually characterised by a high number of alternatives, for example alternative destinations for recreation, people use decision-making strategies that reduce the cognitive burden that evaluation all alternatives and their characteristics can cause. Accounting for the particular characteristics of spatial choice behaviour and decision-processes in study and model design is far beyond common practise in environmental SP valuation studies.

Distance-decay implies that WTP decreases as distance from the agent to the environmental good increases. Such effects are most relevant in case of use-values as they reflect travel cost involved in using such a site, but are also found, be it smaller, in non-use values reflecting option-values for future use. However, of all stated preference studies in environmental valuation, only few studies have reported on distance-decay effects. Very few studies account for such effects in study design, for instance in the sampling method. Disregarding distance-decay effects in the aggregation of individual WTP values can lead to highly overestimated welfare changes.

Substitution effects that arise when an environmental policy programme addresses multiple sites simultaneously are another spatial attribute of stated preference valuations studies that is omitted from many SP valuation studies. Such substitution effects include the effect of both *presence* of available substitutes and *changes in the characteristics* (price and quality) of these substitutes on the WTP for a change in the study site. Sites can be economic substitutes in terms of the use and non-use benefits they provide. Revealed preference studies, such as multi-site travel cost studies, based on Random Utility models are flexible enough to include such effects, but for SP only few examples of multi-program CV studies exist that account for the availability of other improvements at other sites. Most SP studies however, do not go beyond including textual substitution reminders such as recommended by the NOAA guidelines. The focus on a single site may lead to overestimation of WTP. Especially considering the possibilities of choice methods to calculate substitution rates and the increasing number of stated choice experiments in environmental valuation over the last decade, it is very surprising that these studies have not explicitly explored cross-substitution effects.

In addition to substitution and distance, other spatial site and context characteristics are also likely to influence WTP. The effect of spatial site characteristics such as size, structure or shape on WTP is difficult to estimate in studies that include few sites. In particular choice problems, spatial contextual factors include spatial interaction among decision makers, when an individual's WTP is dependent on the decision of other nearby decision-makers. Interactions and interdependency among ecosystems or its components, for instance through diffusion processes, add another level of complexity to environmental valuation. These latter issues are important to determine the entire geographical area that will be affected by quality changes and thus the potential market for aggregation, and describe credible future scenarios of environmental quality changes that respondents will value.

Within environmental valuation based on SP, it has become usual to include maps in the surveys presented to respondents. However, understanding of how people interpret and use these maps in making their choice is a black box which might be opened by studying different disciplines such as social and economic geography. These disciplines describe the way people process spatial information and form spatial knowledge stored in mental or cognitive maps, and how using these maps influences choice-making behaviour. According to this literature, spatial decision-making follows a hierarchical pattern by which people do not simultaneously compare all different alternatives in space, but consider regions or clusters of alternatives from which in the next step they select an alternative. This asks for different models and study designs that account for such decision-making strategies. SP studies in environmental valuation so far have not done so.

The problems identified in the above show that stated preference valuation studies on environmental quality changes have so far been limited in accounting for important spatial variables. Considering the spatial character of many environmental goods, such variables are expected to strongly affect the reliability and validity of WTP estimations, aggregation and transfer outcomes. This paper will firstly discuss different disciplines and their view on space and environment in decision-making behaviour, which will allow for a better understanding of spatial aspects of WTP. Next, an overview will be given of the current approaches in environmental valuation studies using stated preference (SP) to account for spatial aspects, including spatial econometrics and the use of GIS. This paper will recommend ways to improve SP studies and account for the spatial characteristics that many environmental valuation cases embody, based on insights from spatial economics, social and economic geography, environmental psychology and ecology. Throughout the paper, examples of water quality valuation in river basins will be used, but any other environmental asset of which more than one unit is available unequally distributed in space would demand similar adaptations to study design.

2.0 The concept of space in choice behaviour: a multidisciplinary approach

2.1 Spatial choices

In microeconomic theory, on which environmental valuation methods are based, people are expected to behave rationally, consistent, in their self-interest and aiming to maximize their utility. People are assumed to make choices in reaction to changes in their situation, either in their personal socio-demographic situation or in the good of interest. In these choices they have to trade-off these different characteristics or attributes of the goods and their situation.

For spatial choice analysis, two different sets of spatial attributes need to be addressed: (a) the spatial pattern of the social, demographic and psychological characteristics of the affected population and (b) the characteristics of the goods and services under valuation. Spatial choices usually involve choices among particular alternatives at fixed locations and at a fixed distance from the decision-maker. Thus, the alternatives providing the environmental goods and services under valuation are described by three types of attributes: (a) site variables, (b) situation variables reflecting the relative location and (c) separation variables reflecting the separation between decision-makers and the alternatives (Pellegrini and Fotheringham, 2002). Site-characteristics include spatial and non-spatial characteristics such as size, structure and environmental quality that together create use and non-use benefits. Furthermore, most spatial choice problems are characterised by a high number of alternatives. The relative position or situation of alternatives, i.e. the distance between alternatives, influences the degree of competition between alternatives.

Ignoring the second set of situation attributes of alternatives is assuming that they are randomly distributed over space in terms of quantity and quality (for instance the presence of water bodies across a catchment of different water quality levels). Assuming that preferences are randomly distributed over space ignores demographic, socio-economic and cultural differences between regions, or the influence of location and proximity on environmental values. The distribution will influence the substitution effects between lakes and determine (ecological) interaction effects between ecosystem services, which in turn affect aggregation possibilities. Therefore, spatial attributes, such as location attributes, distance, substitutes and context, affect spatial choices through the relationship between people and places.

Choices can be affected by spatially defined social interaction. Besides the personal and psychological factors of decision-making processes, there are social factors, such as reference groups, social class and culture, which stimulate interaction between people in social groups and lead to mutual influences on each others choices and cognitive processes. In environmental evaluation, place-based theory argues that environmental values are manifestations of cultural values constructed from a given perspective in time and space (Brown et al, 2002). Migration and recreation studies in economics sometimes include the notion of social interaction among decision-makers that are in close proximity to one another, which results in spatial correlation among the choices of those decision-makers.

In the mental mechanisms of the cognitive process, motives, affect, attributes, perceptions, beliefs and preferences produce a choice that maximises utility, according to standard utility theory. Thus, spatial choices are the outcome of spatial preferences and perceptions, resulting from spatial attitudes, motives and affect and spatial information. Wheras these cognitive processes of preference maximization are regarded as a black box in economics, they lie at the centre of psychology and behavioural choice theory. The next section goes deeper into spatial knowledge formation and its use in spatial decision-making.

2.2 Spatial knowledge and decision-making

In the field of economic geography, spatial behaviour and the human apprehension of geographic space has been studied extensively, originally driven by the demand to know how people construct, understand and remember geographic information and knowledge. This process is described by spatial or geographic cognition theory, a field that is also supported by psychologists, linguists and anthropologists among others.

Spatial cognition concerns the study of knowledge and beliefs about spatial properties of objects and events in the world (Montello, 2001). Spatial cognition theory states that spatial learning involves three sequential steps. The first step is knowledge formation of landmarks, places that function as reference points in space and are easy to recognize. The second step is route knowledge about trajectories that connect landmarks. The last step in spatial learning is survey knowledge: using maps to learn about interrelations of locations, distances and directions. Thus, when shown a map, people isolate the figures of interest and organize them by relating their locations and orientations to a frame of reference and to other figures, such as landmarks from other categories or hierarchically higher categories. This three-step learning process results in spatial knowledge. This knowledge of landmarks, routes and maps is linked with non-spatial attributes, such as perceived qualities and emotional associations of locations and routes.

Spatial knowledge is stored in a so-called cognitive or mental map, a mental representation of the surrounding environment. In these cognitive maps, the spatial information is loosely connected or stored in hierarchies of different, sometimes embedded, spatial scales and categories (Tversky, 1992). Spatial knowledge thus evolves in time with experience and increased interaction. Frequency of experience with regular travel routes and regions is most important in this learning process, both in knowledge formation and in determining regions. These perceptual regions are personal, following from a certain perception of the surrounding world, and may be reference dependent since location attributes of residencies or other reference points might influence people’s perceptions. The final cognitive map combines information from many different data sources and may result in an impossible figure (Tversky, 1992).

The cognitive map of spatial knowledge is used to make decisions in space. The way information is stored in these cognitive maps influences the effect of spatial information on choice behaviour and leads to ‘distortions’ in how people answer spatial questions regarding distances. The cognitive map shows that spatial knowledge about distance measures in metric geographies is not well modelled by mathematical theory of metric spaces (Montello, 2001). Cognitive maps are not two-dimensional or linear-in-distance. The human mind does not think in mathematical formulas, but makes categories of for instance cities, regions and states. For instance, whenever two landmarks fall in the same category, the distance is underestimated relative to distances between landmarks in different groups. People sometimes use surrogates to estimate distance, such as number of turns and the amount of information remembered (Tversky, 1992). The discontinuity of distance functions is also found in the memorizing process of direction (Franklin 1992).

Tversky (1992) describes three systematic errors that the use of cognitive maps rather than cartographic maps produces in spatial choice behaviour. These errors are due to:
(1) hierarchical spatial information storage or memory, which cause for example that people compute directions between two cities in different regions by the relative position of those regions, and have more difficulty in determining the direction between cities in one region than between cities in different regions;
(2) cognitive perspective, which leads to underestimating distances between two places far away from a perspective compared to distances between two places close by, differences in estimated distances from A to B compared to distances from B to A, and differences in perceived distance among people or activities depending on the geographic location (Worboys, 1996);
(3) cognitive reference points, i.e. landmarks, which distort the space around them and are perceived to be closer to each other and to the baseline position than relatively unknown or ordinary places.

The hierarchical manner of knowledge storage and consequent errors in direction and distance judgements influence the decision-making processes in spatial choices among locations or destinations. As the cognitive task to consider all information on all individual locations is extremely hard, a hierarchical pattern (Fotheringham, 1988) of choice behaviour replaces simultaneous comparison of alternatives. Alternative locations are clustered in groups or (perceptual) regions, according to the spatial structure of the area of alternatives. People first consider and select a larger-scale perceptual regions, before choosing a certain location within that region. In this hierarchical decision-process, information on a specific location might be inferred form information at a higher 'regional' level. Sometimes, non-spatial information about one location is used to facilitate spatial judgment about nearby locations within the same region, but not about locations further away (Franklin, 1992). Using this mental map with different sources of information, such as text, maps and experience from other places, people can also construct preferences of locations they have never seen before.

2.3 Recommendations for environmental valuation

There are at least three main messages from the above to keep in mind when valuing an environmental good in a certain landscape. First, to describe choices, a linear specification of distance is unlikely to capture the character of the cognitive processes, from a psychological and behavioural point of view, because locations of reference (landmarks) and perspective matter and can create non-random spatial distribution of (WTP) values.

Second, spatial choice is likely to follow a hierarchical choice process, in which people choose from perceptual regions, which clusters different locations. The mental maps differ among people depending on their perception, references, place attachment, activities, knowledge and experience.

Third, besides distance, many other spatial attributes, both of locations as well as of respondents, will influence choices. Stated preference studies involving spatial choices, which by nature of the good most do, should take into account these attributes.

3.0 The role of space in stated preference research: an overview

3.1 Spatial attributes of choice

Although many environmental valuation studies essentially involve spatial choices in which both respondents and alternatives are located in space, surprisingly few stated preference studies present empirical results of the effects of these spatial attributes. If at all, the inclusion of spatial aspects of a valuation study often do not go beyond regarding the distance from an individual to the good under study, or mentioning the fact that respondents should consider the existence of alternative locations. In addition to the different choice making pattern underlying spatial choices, there are a list of spatial attributes that are likely to influence WTP:

- The effect of distance (from the agent to the good under valuation);
- The distribution pattern of the environmental good (for substitution effects)
- The distribution pattern of agents (for aggregation)
- Site-characteristics (for benefits transfer)
- Diffusion processes and spatial ecosystem interaction (for in scenario design);

Examples of stated preference (SP) studies that include most or all these spatial aspects of a valuation problem are rare in the literature, if not inexistent. The next sections will address these issues, their theoretical background, the way they have been modelled so far, and discuss the possibility of including them in SP techniques.

3.2 Distance

Hardly 20 SP studies in environmental valuation have found distance from the agent to the asset under valuation to be a significant parameter for WTP (see Appendix 2 for an overview). Based on economic theory, the effect of distance is expected to be negative, indicating a distance-decay effect. Distance-decay (DD) implies that the WTP for a certain site decreases as the distance from the agent to the site increases. Use values are expected to be decreasing with distance, for the same logic as used in travel cost studies: costs of visiting a site increase with every kilometre you have to travel. Travel cost studies and some stated choice studies (e.g. Adamowicz, 1994) on recreation use a price per kilometre to calculate the WTP for a certain site[1].

One of the main reasons to include this distance-decay effect is to determine the size of the geographical boundaries (market size) of the environmental good in question. This market is the population within a spatial area over which the willingness to pay (WTP) values can be aggregated to calculate the total welfare change of the proposed scenario. The distance-decay effect can determine at what distance from a site people are no longer willing to pay anything for the ecosystem service in question. In the valuation of river basins for example, both in the estimation of the WTP-function as well as in benefits transfers and aggregation, spatial effects play an important role. As Bateman et al (2006) show, not accounting for distance-decay in the aggregation procedure can lead to overestimations of total benefits of up to 600%.

Besides the direct cost effect of increased travel distance, distance is often inversely correlated with visitation rates and knowledge[2] about the good under valuation, both explanatory variables in many WTP studies. Sutherland and Walsh (1985) suggest to take into account the relationship between distance and knowledge, as they expected that people living closer to the study site are likely to know more about the site, either via regular media or via own visits or friends and family visiting. Many studies speculate that such a knowledge effect may cause distance decay. Information and knowledge indicators are often found to be correlated with distance (see Pate and Loomis 1997; Concu 2005), sometimes only indirectly (Bateman *et al* 2005). As an indicator of knowledge, studies include length of residency as an indicator of familiarity and attachment to the site under valuation.

Whereas distance-decay of use values has a clear theoretical explanation, there is no reason within standard economic theory why non-use values, apart from the option-

[1] Some tourism studies state that a longer journey does not necessarily creates extra costs, as the trip itself can be enjoyed. Furthermore, a large distance is sometimes considered to be a positive characteristic of a destination, as travellers associated a far away location with relaxation and 'being away far from busy day to day life' or a more adventurous trip.

[2] Knowledge regarding the good under valuation is in general an important issue in SP studies on environmental goods. People are in general not used to valuing environmental goods and expressing their preferences for these goods in monetary terms. Although respondents may not be very familiar with the good itself, rational decision-making requires fully informed decision-makers.

value component of non-use, would also decrease with distance. The spatial discounting literature states that non-monetary values related to economic non-use values (such as intrinsic, life-sustaining and future values) should have much lower discount rates than use values (such as recreational, subsistence, therapeutic and aesthetic values) (Brown *et al* 2002). Results in the empirical literature on this use versus non-use issue are mixed, also because distinguishing pure non-use values from use values is both theoretically as well as practically very difficult. For seals in Holland (Bulte et al, 2005) or for goods with a large share of non-use value (Payne *et al* 2000) no distance-decay effect was found. On the other hand, some studies find non-use values held by users decreasing with distance, for instance for a locally important lake (Sutherland and Walsh 1985). Also for non-users, a distance decay effect is sometimes found (Bateman *et al* 1999; Hanley *et al* 2003).

One could argue that these studies do not test to see if these current non-users will turn to be future users – when quality increases. Bateman et al (2006) suggest that there might be a different distance-decay function for an improvement versus prevention from deterioration for the same site. When the valuation scenario describes an improvement, this conversion is more likely amongst non-users living closer to the site than among those further away, as the closer group has more use-prospects. For an improvement current non-users might thus be tempted to overstate their WTP and aggravating the DD-effect. When the quality does not improve, there is no reason for conversion of non-users to users. Bateman et al find this effect for two different goods, but the hypothesis has so far not explicitly been tested for one and the same site or good.

Other cases in which a distance-decay effect is less likely to occur is for goods that have importance on a large scale. Here, if any, the distance decay effects is likely to be very small, meaning that even very far from the site, people are willing to pay. On the other hand, the fact that something is either of national importance or has the status of national park implies that (a) there are likely to be fewer substitutes – their unique characteristics have lead to a protection status, or (b) that knowledge about the site is widely spread. Loomis (1996, 2000) finds a low DD-effect for salmon, a symbolic species, and Pate and Loomis (1997) don’t find any DD-effect at all for a National Park. Whenever goods have a local importance due to some cultural association with the good, willingness to pay is likely to fall beyond that political/social border. Examples are distance-decay effects found for “local” goods, suggested to be due to a “sense of ownership” (Bateman, 2004) or “spatial identity” (Hanley, 2003).

Another reason for no DD-effects might be that there is more non-response among people living further away, because they are not familiar with the asset or have no interest whatsoever. This spatially defined sampling bias will lead to an underestimation of the distance-decay effect.

In many spatial choice studies, it is impossible to separate substitution from distance effects. For non-unique sites, like a lake in a lake district, the availability of substitutes will increase with distance, lowering the WTP for one particular site. Brouwer and Slangen (1998) find significant distance effects and attribute these to substitution effects. Studies that take include these substitutes in the regression analysis, e.g. by the number of alternative rivers (Brown and Duffield 1995) or by the total surface of substitute sites (Pate and Loomis 1997) still find a significant distance-decay effect. It is important to note that these studies do not account for the distance to these substitute sites. The next section will go deeper into the issue of substitutes in spatial valuation studies.

To account for the effect of distance on WTP, the study design has to include a geographical sampling strategy. The sample should cover such a large area that also non-users are included and distance-decay effects are likely to be captured. There should be enough variation among the respondents in the distance they have to travel to the site under valuation.

Another technical issue in study design is that distance can be specified in many different ways: in a straight –line (as the crow flies) or based on the road net/travel distance, using more sophisticated GIS applications, objective or subjective, continuous or discrete. Travel cost studies typically use GIS based distance calculating, assuming that people minimize their costs by choosing the shortest route. Sometimes in travel cost studies, instead of distance, travel time is used, as the time involved in travelling to a site might be of more importance than the kilometre distance. However, for non-use values, which form a large share of many environmental goods, the least cost travel route does not matter and other specifications might be reliable. As explained in the previous paragraph, social sciences have found that people perceive the distance to well-know goods to be shorter than to unknown goods. The difference between objective and perceived distance can also be caused by natural or political boundaries or obstacles in the landscape. Typically, studies do not use respondent's assessments of the route distance. They may possibly be less accurate but might better reflect perceptions on choice. Especially for goods with a local importance, some studies define a dummy indicator for zones (in km ranges around the asset or for administrative zones) to indicate whether the respondent is a resident of the country/province/state in which the good is located.

Besides the question how distance should be measured, another issue is to which part of the asset the distance should be measured. The figure below illustrates the problem. This issue is also related to the geographical scale of the study and the definition of the good under valuation. Many studies focus on a particular site or small region. When valuating an entire river basin, there is no straightforward approach to the definition of distance. So although including distance might be considered to increase the validity of a study, it is far from straightforward. The question is which distance is affecting WTP most. Ideally, the distance from individual A to access points of a water site should be used for use-values. For small lakes with only few access points it is relatively straightforward to determine the distance. In travel cost studies, distance is commonly taken to the nearest recreation site in the nature area or the entrance point of a National Park. When dealing with larger lakes such as X or river stretches such as Y, it already becomes more problematic as they may have many entry points. When valuing entire river basins with water and rivers flowing at each side of the respondent A, the questions is to which site(s) distance matters.

Last but not least, distance-decay functions can be specified in many different ways and aren't necessarily linear. In the literature, DD functions are specified as linear, parabolic (see Appendix 1 for an overview). However, the interpretation of the specification is never given and there are no guidelines for SP studies on which functional form should be used – other than which specification gives the best statistical fit. So far, there is not enough empirical information to come to a generic distance discount parameter of specification.

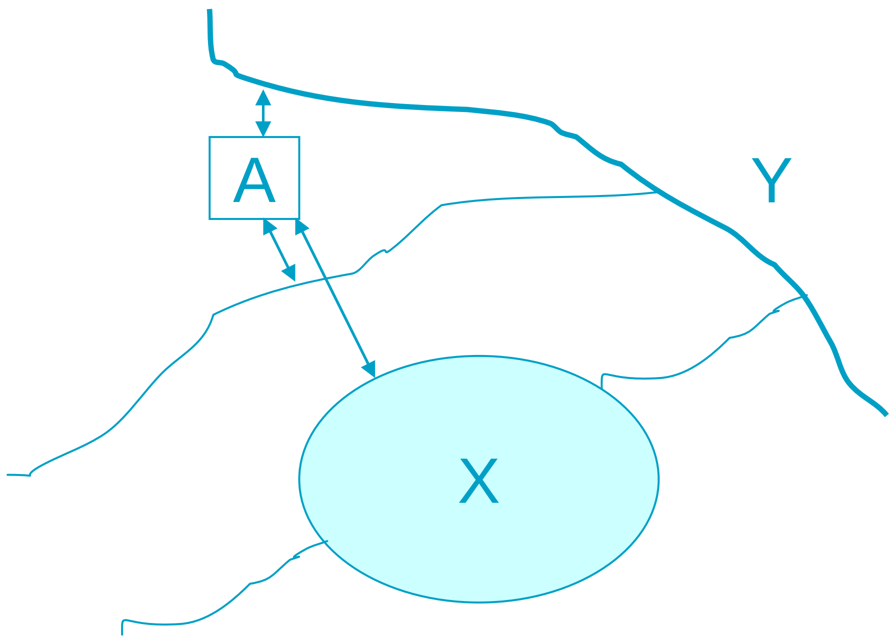

Figure 1 River basin distances

3.3 Substitutes

As distance from the site or the geographical scale of the study increases, the number of substitutes is likely to increase. Since these substitutes are usually not randomly distributed over space, different respondents face different substitutes, which is likely to affect their WTP. In other words, if the WTP of both sites is dependent on distance, the substitution effect will be dependent on the relative distance between the sites. Substitution may also arise when an environmental policy programme addresses multiple sites simultaneously. Thus, the WTP for a site is likely to be dependent on other available alternatives and their characteristics – and the perception of substitutability of these sites. Substitution effects are often omitted from SP valuation studies, but the consequence of disregarding these substitutes is that WTP values may be overestimated.

In general, microeconomic choice theory is based on the notion of substitutability, meaning that in the margin every good has a substitute: because of scarcity, we have to make choices. Choices are the result of a trade-off between the characteristics of two goods. This trade-off is reflected in the marginal rate of substitution (MRS), which indicates how much a person is willing to give up good A in exchange of good B to maintain the same utility level. The marginal rate of substitution reflects a degree of substitutability: the more similar the goods in terms of utility, the more constant the MRS. Substitution properties are related to elasticity, and more specifically to cross-price elasticity: goods are substitutes when a price increase of good A will lead to an increase in demand for good B. Hence, there are two different types of substitution effects that need to be accounted for in estimating the WTP for a change in the study site (Koelemeijer and Oppewal, 1999):

- Availability cross-effects: the effect the presence or availability of another alternative in the choice set. For example in marketing, this is used to study the cannibalization effects of introducing a new product to the existing product range has on the market share of existing products.
- Attribute cross-effects: the effect of a change in an attribute (characteristic), such as price, of alternative B on the probability that alternative A will be chosen.

For water valuation studies of choice among different sites, substitution effects reflect changes in WTP for waterbody A if the water quality in waterbody B increases:

- If WTP(A) remains the same, A and B are independent (MRS=0)
- If WTP(A) decreases, A and B are (imperfect) substitutes (MRS>0)
- If WTP(A) increases, A and B are complements (MRS<0).

Substitution rates are likely to differ among individuals and sites. The perception of use-oriented people depends on activities that a site can provide and these people might substitute a site for any other site where they can perform a similar activity (Brown et al, 2002). This would imply that both values for site characteristics as well as substitution rates differ among user-categories creating heterogeneity in preferences. In environmental psychology, the notion of “place attachment” (and related notions of ‘sense of place’ and ‘rootedness’) explains that people have a functional attachment to landscape and show attachment through emotional and behavioural actions (Bricker and Kerstetter, 2000). Place attachment consists of two dimensions: place dependence (determined by how well a place functionally facilitates the user) and place identity (a combination of values, attitudes, thoughts, beliefs, and behavioural tendencies). The notion of “place identity” describes these deeper values, associated with emotional and symbolic meanings. Besides increased use, length of residency also increases the deeper values that people hold for sites.

Substitution rates depend on the level of similarity of sites in their provision of goods and services of environmental values, but also on other spatial site-characteristics, such as size, structure or shape. Perceptions of spatial characteristics are personal, dependent on context and experience. This may lead to very different images of spatial attributes, including distance, than presented cartographic maps. In stated preference studies of spatial choice, spatial site-characteristics affect choices even if they are not made explicit in text. In a survey on alternative land-use development options, which were presented on simplified maps of the area, people responded to changes in land-uses, proximity to roads, location and other spatial context factors even when they were not explicitly communicated in the text of the survey (Johnston et al, 2002). Besides distance, other spatial landscape characteristics, such as open space, diversity and fragmentation, panoramic views and visibility, elevation and surrounding land-use, can be important elements in perceptions on recreational sites and housing.

Most SP valuation studies focus on the WTP for improvements at a single site. A well-designed study should ensure that the respondents take relevant substitutes into account when formulating their WTP. The focus of a study on a particular site may draw all attention (and thereby WTP) to the study site, thereby reducing the notion of substitutes and overestimating WTP[3]. To avoid overestimation, the NOAA panel requested to give a reminder of substitutes or alternative spending possibilities in the light of scarce income. However, Loomis et al (1994) did not find any significant effects on WTP estimates of reminders of substitutes, so the effectiveness of reminders might be small or negligible.

In single site studies, the possibilities for accounting for substitution are limited, and so are examples in the literature. Sometimes external data on the presence and amount of possible substitutes is included. Brown and Duffield (1995) include the number of

[3] Similarly, disregarding complementary sites causes underestimation of WTP. Complementarity occurs when goods are consumed jointly, or when there are synergy-effects in production.

alternatives, and Pate and Loomis (1997) include the acreage/surface; both studies found a negative effect of substitutes on WTP. Other indicators of substitution effects, such as a dummy variable for visits to substitutes in the region or ratio of visitation rates relative to other alternatives, or the cost of visiting other sites or the distance to these sites, have never been included in the WTP-function of SP studies.

There are a few examples of multi-program CV studies that account for the availability-effects of other improvements at other sites. Multi-program CV studies present different programs to the respondent simultaneously and ask respondents explicitly to value the study site as well as its alternatives. Hoehn and Loomis (1993) asked respondents to value 5 different packages/programmes in the same region separately and combinations of 2 and 3 packages together. In the utility function, the systematic or observable component V can be specified in a linear form as: $V = \lambda i - \beta P$, where i is a dummy for each of the combinations of programmes, taking the value 1 if a combination is chosen, and P is the (total) price of the chosen combination. Hoehn and Loomis only found substitution effects. Another example can be found in Hailu *et al* (2000), who asked respondents to choose as many single packages, each with a particular price, as they were willing to pay for, so that respondents could make their own combinations. They found only positive interaction terms between the programs, implying complementary effects of goods in the same region. However, this may also be due to people just preferring bigger packages.

For studying these substitution patterns among sites, random utility models (RUM) are technically best capable of including characteristics of other alternatives in the utility function of a site. Multi-site travel cost studies are based on RUMs and can estimate these substitution effects, but since these studies use revealed preference data they cannot capture non-use values. Discrete Choice Experiments (CE) are based on the same RUM and attribute based utility theory. In a CE, substitutes can be included in the choice set as alternatives to the site under study among which the respondent has to choose his most preferred alternative. Thereby, CE offers the possibility to calculate marginal rates of substitution by estimating cross-effects. Surprisingly few CE studies in environmental valuation explicitly address the substitution effects between sites, and there is no study that specifically estimates cross-substitution effects. Most CE studies focus on the marginal values attributed to certain characteristics, for instance water quality or recreation possibilities, which are considered to be generic for similar locations, such as all lakes or rivers.

Within CE studies, the standard multinomial logit models (MNL) is most often used to analyse discrete choice data. MNL models assume equal substitution ratios among alternatives under the IIA assumption, implying perfect substitution among all alternatives. The IIA assumption is easily violated when certain sites are better substitutes, for example because of spatial proximity, continuity, and location characteristics. MNL models also assume that all alternatives are considered simultaneously in the choice process. Over the years more advanced models, such as Nested Logit (NL) and generalized extreme value (GEV) models emerged, which can include different substitution patterns and relax the IIA assumption. The nested logit model assumes that the IIA assumption holds within nests, that is groups of alternatives, but not between groups. The 'mother logit model' defines the utility function of an alternative in terms of both its own as well as its substitutes' characteristics (McFadden 1975). Open-form models (based on simulation) such as random parameter models (RPL) or mixed logit models and latent class models, also allow for more flexible substitution patterns. They do not contain the IIA property and are consistent with random utility theory. In short, mixed logit models allow correlation in unobserved utility part over alternatives by including coefficients that vary in the population. They account for preference heterogeneity. Hunt et al (2004) give examples of applications of the mixed logit in migration and transport studies, in which the error component of the model includes a spatial weight term (again the distance between alternatives). Most probably, this development in choice modelling is most promising, when better integrated with spatial econometric approaches to capture interdependence of both respondents and sites statistically.

Considering the complexity of such approaches, various studies explore the applicability of closed-end models that allow for more flexible substitution than the MNL model, and at the same time account for the spatial attributes and spatial choice behaviour. Although the NL model with its hierarchical structure seems to be capable of modelling the psychological process behind site choice (as described in section 2), in fact it is the analyst who *a posteriori* decides on the *discrete* variable that distinguishes the different nests in the model. Fotheringham (1988) argues that for spatial choice the variable that distinguishes the various alternatives distance. Since distance is continuous, the discrete NL approach of grouping alternatives is not applicable. The equal substitution rate within nests that NL models assume will also not hold if the distance between the alternatives varies. This is almost always the case for water bodies; they are far from equally distributed over space. Furthermore, perceptual regions are known to be different for each individual and depends on experience, knowledge, etc.. The perception of regions creates heterogeneity among respondents. Any definition of nests by an analyst to apply a NL model is then very arbitrary.

Fotheringham (1988) argues that if the WTP of both sites is dependent on distance, the substitution effect will be dependent on the relative distance between the sites. Proximity to similar sites may increase the probability that a site will be chosen in case of agglomeration effects among sites, whereas with highly competitive markets, proximity to alternatives reduces this chance. Just including distance from the agent to the substitutes, as is as far as current SP studies of environmental valuation go, therefore does not account for the proximity of substitutes, the spatial structure of the distribution of alternatives. To capture the degree of competition among destinations in discrete choice models, different so-called accessibility indicators have been developed, which indicate the degree of similarity in access. The specification of both Borgers and Timmermans (1987) and Fotheringham (1988) account for the spatial structure and substitution. Fotheringham's specification of the accessibility term (a_i) includes a measure of the attractiveness of alternative j (W_j) and d_{ij} is the distance between the alternatives:

$$a_i = \ln\left(\frac{\sum_{j\neq 1}^{J} W_j}{(J-1)\sum_{j=1}^{J} d_{ij}}\right)$$

The type of Fotheringham indicators is now considered to model the probability that a destination will be considered by the agent and included in the choice set of relevant alternatives (see Hunt et al 2004), and thereby captures the hierarchy in choice behaviour. Such an indicator can be included in stated CE in the utility specification as another variable of an alternative.

Although CE in which respondents are asked to choose among various sites offer the possibility to calculate cross-effects among these sites, stated CE are limited in the number of alternatives that can be included in the design. Recreation and site choice studies that work with large datasets of revealed preference data often focus on large numbers of substitutes sites within a region. The context of many studies is often one with many alternatives, but including too many alternatives in a stated choice task will impose a high cognitive burden on respondents and may lead to heuristics in decision-making. This consideration leads to the question which waterbodies to include in the spatial choice set (Parsons and Hauber, 1998). Most SP studies, both contingent valuation and choice experiments, cut down the number of alternative sites in order to keep the valuation study simple. Different criteria have been used to determine the relevant alternatives:

- All waterbodies in the catchment of a similar type (objective)
- All waterbodies in the catchment (objective)
- All waterbodies known or visited by the respondent (perceived)
- All waterbodies within a certain range of the respondent (objective)

Since water recreation is just one of many recreational activities, one could even argue to include all recreation and nature sites. Even substitute waterbodies outside catchment area will compete with waterbodies at the frontiers of a study area and create so-called edge effects. In choice set specification for CE, two general approaches exist, both in which the analysts determines the set: either to include all possible locations whether relevant or not, or to arbitrarily predefine a subset of alternatives that are most likely to be relevant, for instance because they are located within a reasonable range from the respondent's location. Ben-Akiva and Boccara (1995) model the availability of a site in the choice set as a function of personal constraints, and base the choice set on a maximal distance range within which available alternatives should fall. Parsons and Hauber (1998) argue that substitutes that are not known by the respondent should not be included in the choice set, but agree that there is possibly some degree of awareness regarding far-away sites[4].

[4] One could argue that for non-use values of non-users (apart from option values) are not dependent on distance and therefore distance should not influence substitutability.

In the design of a stated choice study, choice set specification problems can either be addressed after the data collection in the model specification or integrated in the survey design. The data collection method might be made flexible so to adapt the alternatives shown to the respondent, either based on knowledge, experience or distance to the sites. This information could be asked in general questions prior to the CE itself. Furthermore, a design with flexibility in the alternatives shown to a particular respondent also asks for a specific experimental design. Rose and Hensher (2004) give an example of flexible choice sets in a SP survey. In this study on transport, some of the alternatives are not considered to be relevant to all respondents – in this case, because not all respondents own a car. By asking question prior to the CE itself, they construct choice sets with only the relevant alternatives. The main contribution of this paper is the flexibility in the statistical (D-efficiency) design behind this CE though. The authors say that by including only relevant alternatives and relevant attributes, the CE itself will become more realistic and respondents are able to handle more complex tasks.

3.4 Site characteristics and benefits transfer

Benefits transfer (BT) implies that the WTP estimate of an original study site is transferred to a new unstudied policy site, based on a certain degree of similarity between the two sites, either by value transfer or by value transfer functions[5]. Many BT studies in environmental economics transfer values over space. The possibility or accuracy of applying BT (Brouwer, 2000) may therefore be limited. The similarity across sites should be in terms of the population and its socio-economic characteristics, site characteristics (such as size, quality, structure, and shape), commodity and change in level of provision of the environmental good. A major restriction for BT is data availability, certainly for BT based on SP studies. GIS can help accounting for many of these spatially defined factors: population size, socio-demographics, distance, site-characteristics including recreational services and landscape, and substitute availability (e.g. in terms of distance or travel time to these substitutes) (Bateman et al 2006). However, since only few SP studies account for

[5] Rather than aggregating the WTP for one good of one individual of the sample up to the WTP for that good of the entire population, BT implies that the WTP of one site is used to estimate the WTP of another site. This WTP can either be from the same or another population.

distance and substitution effects, the reliability of such WTP values may generally be questioned.

If the effect of such spatial site characteristics such as size, structure or shape on WTP, apart of course from the characteristics that will change under the proposed scenario, was known, BT could transfer the WTP function that controls for such characteristics. However, the effect of is difficult to estimate in statistical analysis; only in case data of many sites that vary in these characteristics are available, such effect can be included in regression analysis. Zandersen et al (2007) present a nice example that uses a RUM value transfer function that includes variables for many forest site characteristics (such as size, number of species, type and age of trees, fraction of open land and water bodies, and distance to coast and viewpoints) and population characteristics. GIS can again be very helpful in this process.

3.5 Aggregation

Aggregation implies the estimation of the total WTP of a population by applying the individual WTP value-function from a representative sample to the entire population. As was first demonstrated by Smith (1975) and adopted later on by Loomis (2000), including distance in the WTP function that is used for aggregation can make an enormous difference in the total benefits estimate. The main question is what the size of the market is, so over the population living in which spatial area the WTP should be aggregated. As stated in section 3.2, ignoring distance-decay effects in the aggregation can lead to overestimations of total welfare changes of up to 600% (Bateman *et al* 2006).

Distance is not the only spatial attribute that aggregation should account for. A very illustrative example can be found in Bateman *et al* (2006), who compare different aggregation methods and assess the effect of neglecting different distance-effects: non-response, distance-decay and socio-economic differences between counties. They found that non-response and WTP in principle were both negatively related to distance, and corrected for the effect of self-selection. Self-selection bias occurs when underlying values affect the act of replying to a survey at all; when only interested and therefore WTP individuals reply, aggregating their WTP over the total population will lead to overestimation. Bateman *et al* (1996) corrected for this by assuming that non-respondents will not be WTP. In the final aggregation procedure, they apply the valuation function and calculate values for each county, taking into account the difference in distance to the site and the socio-economic characteristics of the counties. Thereby, the variability of values across the entire economic market area is better represented in the total WTP. The study also presents GIS based value maps to visualize the distribution of WTP over space.

3.6 Diffusion processes, spatial interdependence and spatial interaction

Many environmental SP studies measure the benefits resulting from a change from the current state to a future state of an ecosystem at a certain location. Valuation of water quality often studies water catchments in which the individual water bodies are interacting and ecosystem functions are interdependent. This may cause spatial diffusion processes, e.g. when pollution of a waterbody upstream negatively affects downstream quality levels. And although microeconomic theory of valuation assumes substitutability of environmental goods and services that have use and non-use values, the components of the ecosystem may be interdependent making them complements in functionality. An ecosystem may not be able to produce certain services without the availability of other functions. Hence, understanding the diffusion processes and interdependencies of ecosystem functions may help to (a) determine the entire geographical area that will be affected by quality changes and thus the potential market, and (b) describe credible future scenarios of environmental quality changes that respondents will value. The size of the impact determines the size of the economic market: for example, a water quality upstream can create benefits all the way downstream. The diffusion of pollutants through the river system also determines the scenarios that are compared. Knowledge of hydrological fluxes will therefore ensure credibility of the proposed scenarios.

However, other than in determining the scenarios and size of the market, SP studies usually don't take into account the time-space side of diffusion processes of pollution processes. Spatial interdependence of water sites, for instance when pollution on one site changes the quality of another site, can be accounted for by capturing the interactions and substitution effects between sites. However, as described in section 3.3., such effects have not been estimated in SP studies, and hence not for non-use values. Choice experiments on site choice would however offer the possibility to assess changes in WTP for a site due to quality changes in another site by assessing the consumer surplus of different scenarios in which these effects are included.

The human set of the spatial characteristics includes the diffusion of people and their activities over space, and also knowledge diffusion. Social studies have found evidence for spatial heterogeneity in environmental perceptions and attitudes (Brody 2004). Spatial interaction models take into account that decision-makers can influence each other. The strength of this interaction is often assumed to be dependent on distance; the closer two agents are located, the stronger the interaction effect. Thus, rather than modelling the proximity of destinations, this heterogeneity is present among decision-makers. This spatial correlation is modelled by using weighting matrices, which often include a proximity indicator of the sites to reflect the similarity. These matrices are sometimes defined based on a continuous distance metric, but often contiguity matrices with dummy variables for adjacent locations are used.

Spatial econometrics and statistics are often applied to model spatial effects. Different types of spatial patterns are addressed: spatial lags, spatially correlated errors and spatial drift. Spatial lags are used to model spatial interaction among decision-makers. They capture the idea that individuals are directly affected by the *known* decision of other individuals, for instance in group decision-making and interacting agents (Bradlow et al, 2005). Spatially correlated errors can be due to omitted variables that determine choices, which can be inferred from respondent proximity. The omitted variables follow a spatial pattern. So even when accounting for population distribution, distance-decay effects and the spatial distribution of socio-demographic variables such as income and education (when found to be significant in the WTP function), some spatial correlation in the error term of the WTP function might still be found. Spatial drift models capture the idea that model parameters (so not the choice per se!) are a function of an individual's location on the map. As such, they can capture the effect of certain locational effects on perception, which in turn drive choices. Again, apart from including a dummy for residence to capture a difference in perception, such effects have so far not been included in SP models.

4.0 Conclusion and Discussion

The relevance of spatial attributes in environmental valuation might seem obvious, but incorporating spatial attributes in stated preference (SP) studies of is far from common practise. Especially for studies on the WTP for changes in environmental quality of sites for which many substitutes are available, site-characteristics, distance to respondents and distance among sites will influence substitution patterns and the WTP for a site.

Substitution and distance have not been accounted for in the majority of SP studies. Since SP techniques are based on surveys, they often simplify valuation scenarios, for instance by reducing the size of the choice set or by limiting the description of substitutes and their effects, to reduce the cognitive burden for the respondent. This limitation also reduces the possibilities of estimating site-characteristics – other than those that will change under the proposed environmental scenarios – on WTP. There is no SP study in environmental valuation that accounts for the effect on WTP of distance between respondents to substitutes and the distance among substitutes.

The psychological processes of spatial choice in environmental valuation are not well understood in general, let alone incorporated in the environmental valuation study design *a priori* or statistical analysis *a posteriori*. Environmental SP studies with spatial elements hardly ever make use of insights of social geographers on how people store spatial knowledge and how such knowledge structure are also reflected in hierarchical choice making. Regarding the development of statistical models, applications of geographic analysis methods and spatial statistics have only recently been introduced in environmental valuation, but have not yet been embraced by SP practitioners. Related to this, GIS is a good example of a tool which could be used far more intensively than only to generate visualizations of case study areas and has clear advantages to improve the reliability and validity of benefits transfer and aggregation. Last but not least, and especially important for water quality valuation, many SP studies do not account for spatial diffusion processes and interdependencies among environmental sites and only consider the substitutability of ecosystem components in economic terms and from the perception of the consumer.

This paper is a first start to bridge the gap between the current state of the art SP practises and knowledge from different disciplines, such as geography, environmental psychology, travel and leisure sciences, and spatial econometrics. The limitations of SP studies combined with the complexity that ecosystem functionality often brings along may lead researchers to disregard typical spatial site-characteristics and contextual factors, including substitution effects. Between contingent valuation and choice experiments, CV is most useful for single area studies or unique sites – for which distance and substitute issues may be less relevant, but CE seems to offer the best possibilities to capture substitution effects between alternatives. CE on choices among sites at a local scale can reflect the influence of site-specific characteristics.

The literature from other fields gives insight in new approaches and considerations, for both study and statistical model design. The most important suggestions from this literature review for spatial SP studies for environmental valuation, both for the development of study design and statistical analysis, are:

(a) to account for spatial decision making behaviour and hierarchical choice processes in a context with many available substitutes, for instance the scale at which alternatives are selected and the way they are presented in the survey;
(b) to build models according to this spatial decision making process that also reflect the extent to which choice-makers consider their alternatives;
(c) to include distance as an explanatory variable in the utility-function and consider other measure of distance besides shortest route distances, such as perceived distances;
(d) to take into account for possible spatial heterogeneity among decision makers due to location effects;
(e) to apply a sampling strategy which is not only based on socio-economic factors such as age, gender and income, but also on the geographic distribution of these characteristics, and distance;
(f) to consider in the valuation of a particular site the effect of substitutes, both in their spatial and non-spatial characteristics – and develop methods to do so when only few sites or site-characteristics can be included in the valuation question itself;
(g) to account for the spatial structure, that is the pattern or distribution of sites and substitutes over the area, to reflect the substitutability of those sites due to their relative location.

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APPENDIX 1

Function	**Formula**
Linear	$D = a_0 D$
Log-linear	$D = a_0 \ln D$
Gamma	$D = aD^{a_1} e^{(a_2 D)}$
3rd Polynomial	$D = a_0 D + a_1 D^2 + a_2$
Exponential Law	$D = a_0 \exp(-D)$
Beckmann Law	$D = \frac{a_0}{1 + D^2}$

Table 1 Functional forms of distance variable (Concu, 2005)

APPENDIX 2

Table 2 Overview of Contingent Valuation studies with significant distance-decay effects

	Authors	Year	Distance/Prox	Good
1	(Sutherland and Walsh)	1985	Miles one-way	Regional freshwater rivers and lakes, USA
2	(Carson, Wilks, and Imber)	1994	Dummy: state	National Ecological and cultural heritage
3	(Brown and Duffield)	1995	Miles one-way	Instream flow
4	(Loomis)	1996	Kilometres (one-way)	Iconic species
5	(Bateman and Langford)	1997	Dummy >110 km	National Park
	(Moran)	1999	Kilometres	National Park
	(Bateman et al.)	1999	Kilometres	National Park
	(Brouwer and Bateman)	2005	kilometres	National Park
6	(Pate and Loomis)	1997	Kilometres	Iconic species
7	(Breffle, Morey, and Lodder)	1998	0.1 mile	Small scale
8	(Brouwer and Slangen)	1998	Kilometres	Wildlife preservation in peat meadow land
9	Loomis	2000		
10	Bateman et al	2000		
11	(Daun and Clark)	2000	Kilometers	Flood risk
12	(Georgiou et al.)	2000	miles	River in urban area
	(Bateman, Georgiou, and Lake)	2005	Kilometres	River in urban area
	(Stumborg, Baerenklau, and Bishop)	2001	Dummy?	Lake Mendota, IS, residents
13	(Hanley, Schlapfer, and Spurgeon)	2003	Kilometres	Low flow in one of many rivers
14	(Bateman et al.)	2004	Dummies: visitation and zone	Mountain lakes

Table 4 Overview of Choice Experiment studies with distance effects

	Authors	Year	Distance/Prox	Good
1	(Adamowicz, Louviere, and Williams)	1994	Kilometres	Water recreation
2	(Adamowicz et al.;Boxall et al.)	1996, 1997	Kilometres	Moose hunting
3	(Hanley, Mourato, and Wright)	2001	Kilometres	Rock climbing
4	(Concu)	2005	Kilometers	Nature Park Australia

CASE STUDY APPROACH

To address the issues above in a water quality context, the following case study will be developed:

A valuation scenario on water quality improvements in 10 major lakes in the Netherlands, specifically in the Rijn-West area or the Randstad. In the Choice Experiment part of the study, people are first asked to choose between 3 alternatives. Those are the lakes closest to their home location (under the assumption that those alternatives are most important). The current water quality is bad, and in the hypothetical scenario the quality can improve to moderate or good quality. The second attribute is price. People are asked to choose their most preferred alternative from the 3 lakes, which are depicted on a GIS-map. In the second set of CE questions people are asked to choose between 7 out of 10 lakes, where water quality improves with a certain price level, the other 3 remaining at bad quality and price zero.

The remainder of the questionnaire includes as many as possible question on relevant perception, attitude and socio-demographic characteristics, as well as address.

The underlying design will be based on a D-efficiency design generation method. Both *availability and cross-attribute effects* will be estimated. The influence of the *spatial structure*, based on proximity of alternatives, on the *substitution pattern* will be modelled by different GEV and ML specifications, with special attention for possible spatial hierarchical choice structures. Different *distance-decay* functions for different lakes will be estimated, by trying various functional and metric specifications. Tests for violations of IIA will indicate if heterogeneity among decision-makers is present, and if so, spatial correlations in the error structure will be analysed by applying spatial econometric approaches.