# The spatial range of public goods revealed through referendum voting

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**Abstract**

Billions of dollars are now spent annually in the United States and Europe for spatially delineated environmental services such as agricultural landscape management and river restoration programs, yet little is known about the spatial distribution of the benefits from these policies. This paper develops a framework for recovering information on this question from the spatial pattern of votes cast for referenda on the provision of spatially delineated public goods. We specify a model linking voter support for environmental improvement to the distance at which such improvements are expected to occur. The empirical application is to a river restoration referendum in the Swiss canton of Bern. Our results indicate that the benefits from river restoration have a strong local component, sufficiently strong that voter approval would not occur if only canton-wide benefits were at stake. Surprisingly, support for river restoration is no greater, and in some specifications is actually lower, in locations where rivers are a prominent feature in the environment.

## 1. Introduction

Many traditional public services such as ambulances or national defence have benefits accruing to fairly well-defined local, state or national populations. However, there is a range of more recent public policy interventions with a distinct spatial dimension, many related to aspects of environmental quality, for which the spatial distribution of benefits is not obvious. Environmental examples are the restoration of natural habitats and protection of endangered species and ordinary wildlife. Individuals value such programs, even though they necessarily occur apart from where people actually live. Examples from an urban setting include community redevelopment, planning programs and crime reduction initiatives.

It seems useful to distinguish two levels at which questions regarding the spatial analysis of benefits can be addressed, each with its specific applied potential.

The first, *qualitative* level concerns the spatial range over which *any* willingness to pay (WTP) for the local public good is observed or, in other words, the "extent of the market". Information about the spatial range of benefits alone (without quantification of these benefits) would be useful for assigning responsibilities to appropriate levels of government in a federal state. If the jurisdictions responsible for decision-making and financing of a public service reflect the range and distribution of its benefits, then efficient provision is compatible with democratic decision-making (Oates 1972, Cornes and Sandler 1996, Loomis 2000). Additionally, the spatial extent of damages from environmental degradations is a controversial and contentious question that arises in assessing natural resource damages. According to Smith (1993, p. 21) "Definitions of the extent of the market are probably more important to the values attributed to environmental resources as assets than any changes that might arise from refining our estimates of per unit values."

The second, *quantitative* level of analysis is more demanding and concerns the magnitude of willingness to pay as a function of the distance and quantity or "scope" of the spatially delineated resource damage or improvement. Such information is needed if the purpose of the analysis is to obtain monetary estimates of resource damages or benefits of proposed policies. How do individuals value the distance and quantity or abundance of any resource to be protected? Intuition suggests that an individual would be willing to pay more to raise a resource to any given level of quality if the resource is close to the individual and if the extent of the resource is large rather than small. For instance, raising the quality of local rivers to a pristine level would seem more important if rivers are close to settlements and if they dominate the landscape than if they are distant and relatively inconsequential in scope.

There are in principle several options for addressing questions on the spatial distribution (and basic character) of such preferences. Perhaps the most frequently used method for the generic problem of measuring public good benefits is contingent valuation, in which surveyors ask respondents their willingness to pay for hypothetical variations in a public good. Hedonic wage and housing price studies constitute a second approach, in which values are inferred from the price differential individuals pay or receive for public goods consumed as a consequence of living in a certain neighbourhood or working at a certain job. A third method, based on a specific political model, links attributes of a jurisdiction's median citizen with public good outcomes. Each of these approaches has been criticised on various grounds (Kahn and Matsusaka, 1997). We are unaware, however, of any study that has examined the spatial nature of benefits with results from referendum voting.

Relying on ballot choices is attractive in cases where public good levels are decided by referenda. In such cases, the individual's voting choice reveals a preference. Observations on these revealed preferences, together with relevant prices and individual attributes, can in principle provide information on benefits received in the same way that individual consumption choices reveal benefits in a conventional market setting (Bowen 1943, Deacon and Shapiro 1975, Noam 1981, Kahn and Matsusaka 1997). The choices made by voters have binding consequences, unlike the hypothetical choices framed in CV studies.[1] The electoral

[1] The NOAA panel, whose recommendations have strongly influenced valuation methodology, recommended framing CV surveys to simulate a referendum choice. See Arrow et al. (1993).

process often provides information on the pros and cons of different ballot options prior to elections, so voters are exposed to relevant information. There is no need to assume that the good in question can be enjoyed only by those who reside in a particular location or are employed in a particular job. Finally, one need not invoke a particular theory of political outcomes in order to draw inferences; an assumption that individuals are informed and vote in their self interest is sufficient.

Our aim is thus to develop and apply a framework for analyzing the basic character and spatial distribution of benefits for a spatially heterogeneous public good, based on preferences revealed through voting on referenda. Unlike most empirical voting studies we do not assume that all voters consume the same level of public good *ex ante*, or that they face exactly the same potential public good augmentation. Rather, we incorporate the fact that pre-policy public good levels generally differ across space and also allow voters' expectations on public good augmentations to vary spatially. Further, the public good we examine is restoration of an environmental resource, and the abundance of this resource varies spatially as well. By exploiting this spatial variation in quantity, we can also examine whether individuals value both the quality and quantity of the resource to be restored.

The paper proceeds as follows. Section 2 briefly reviews the relevant literature on voting models and spatial analysis of public good benefits. Section 3 develops the empirical model for the specific context of river restoration. Section 4 presents the empirical application and results and Section 5 concludes.

## 2. Background

### *Spatial distribution of public-good benefits*

Two main approaches have so far been used to examine the spatial distribution of the benefits of public goods, the hedonic pricing technique and contingent valuation.

Hedonic property pricing models are particularly appropriate to the task as they specifically reveal buyers' preferences over housing attributes, including local public goods. Geographic information systems (GIS) can be used to construct variables for local public goods based on spatial relationships between the observed properties and the public goods of interest. A number of studies used this approach to estimate the benefits of proximity to open space (Irwin 2002, Geoghegan et al. 1997, Geoghegan 2002, Acharya and Bennett 2001). All of these found that, when compared to residential, commercial or industrial uses, open space located within a given distance from a property has a positive impact on property price. Another series of studies found that house prices were negatively affected by animal production facilities within given distances (Abeles and Connor 1990, Palmquist et al. 1997, Herriges et al. 2005, Ready and Abdalla 2005). Several studies found that the observed effects depended on the distance between the individual house and the environmental effect examined (e.g. Palmquist et al. 1997, Geoghegan et al. 1997, Acharya and Bennett 2001, Ready and Abdalla 2005). This literature is reviewed in Ready and Abdalla (2005). However, an important limitation of these studies is that they are only able to recover values to the extent they are reflected in housing prices.

Contingent valuation (CV) can in principle be applied to any type and spatial scale of public goods. Loomis (2000) includes distance to policy sites in models of stated WTP for wildlife protection programs. Using the estimated distance-decay parameters he computes the percentage of total economic benefits that fall within the relevant state or regional jurisdictions. Other studies that estimated benefits based on distance decay functions include Pate and Loomis (1997), Bateman and Langford (1997) and Bateman et al. (2000). However, when validity tests are built into survey designs, researchers sometimes find that stated willingness to pay for improvements seems to decay too slowly with distance to be consistent with economic theory. Hanley et al. (2003) found that the distance-decay of stated WTP for improving one arbitrarily selected river of the Thames region implied aggregate values that were several times higher than the benefits implied by the same respondents' stated values for improving all rivers of the region. This result is closely related to findings in the literature on "scope effects" or "embedding effects" in CV. This extensive literature addresses effects of the quantity of a good more generally (rather than of its spatial dimension).[2] It has been argued that stated values in such cases are sometimes more similar in nature to "attitude expressions" on an arbitrary scale than to economic values (Kahneman et al. 1999, cf. McFadden 1999).

Voter preferences have not been systematically used for assessing the spatial range and distribution of the benefits of natural resources. Due to the limitations of the above approaches it is of interest to examine the potential of voting data for these purposes.

*Voting models*

Two of the earliest studies to use voting data to infer public good demand are Deacon and Shapiro (1975) and Fischel (1979), both of which yielded suggestive but promising results from state-wide environmental referenda. In another early study Rubinfeld (1977) examined individual voting data on an educational referendum and estimated the relative effects of income and tax obligation on voting choices. More recently, Kline and Wilchens (1994) related voting returns on open space referenda in Pennsylvania and Rhode Island to such socioeconomic determinants as housing price appreciation, population growth, and farmland loss. Kline and Wilchens (1994) subsequently examined votes from 16 environmental propositions, focusing on the role of income as a determinant of votes cast and on factors linked to the costs a policy imposes. Kotchen and Powers (2006) extended the literature by examining determinants of the overall vote totals for a large number of open space referenda, emphasizing the factors that contribute to the appearance of such referenda as well as the effect of funding mechanisms on voter approval.[3]

While the main intent of the preceding studies was to better understand the factors that influence public good demands, other researchers have examined voting data with the intent of validating CV estimates of environmental benefits. Schläpfer and Hanley (2006) developed a method for recovering willingness to pay from aggregate voting data and tax schedules and compared the resulting estimates to CV results.

None of these studies has examined the spatial pattern of votes in connection with spatial variation in public good provision. Kotchen and Powers (2006) find that outcomes vary for different levels of government and interpret this as suggesting spatial spill-ins between jurisdictions and a spatial dimension to open space benefits. They do not pursue this point, however. Schläpfer and Hanley (2003) and Schläpfer and Witzig (2006) use ad-hoc

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[2] Boyle et al. (1994) investigate WTP for preventing wild ducks from being injured by flying into contaminated ponds. They find that the amount CV respondents were willing to pay was independent of whether the CV questionnaire stated that 2,000, 20,000 or 200,000 ducks would be saved. McFadden (1994) finds that WTP for 57 wilderness areas was only about fifty percent higher than WTP for one wilderness area alone.

[3] Noam (1981, 1982) modelled both the decision of whether to vote or abstain and the ballot choice if a vote was cast. The resulting approach was used to examine demands for a variety of public goods in Swiss cantons.

specifications to relate approval rates in voting decisions about the provision of public goods to local levels of these public goods. The former study found that increased public financing of landscape amenities was positively associated with local (municipal) levels of these amenities. The latter study related local support for regional-level river restoration to local river "naturalness" as measured by eco-morphological data. The authors find some evidence supporting the hypothesis that demand increases with decreasing naturalness of local rivers.

The present paper contributes to this literature by developing a consistent analytical and empirical framework to analyze the spatial range of public goods using voting data. This framework is then applied to the river restoration dataset of Schläpfer and Witzig (2006) and the questions posed earlier, regarding the effect on WTP of distance from the voter and the local abundance of the resource to be restored, are examined empirically.

## 3. Model

The spatial distribution of votes should reflect the spatial distribution of benefits voters perceive from improving river quality at various distances from where they live.[4] For example, suppose the quality of a *single* river is to be improved and river quality is a nationwide public good so the benefits consumers experience are independent of their distance from the improvement. In this case, assuming identical tastes, incomes and tax liabilities, voters at all locations will be equally likely to vote in favour of restoring this single river. Alternatively, if river quality is a local public good so the benefits from improvement diminish with distance, then those living near the river will be more inclined to vote for an improvement than those living far away.

Similar reasoning can be applied to the spatial pattern of voting on a nationwide referendum that would enhance river quality at all locations. If river quality is a nationwide public good then voters living near degraded rivers and voters living near pristine rivers will be equally likely to vote for it. This is true because river enhancement at *any* location would confer identical benefits on all voters, regardless of where they live. If the benefits from enhancement decline with distance from the voter, however, voters living near degraded rivers will be more likely to vote for the proposal than those living near pristine rivers. There are two reasons for this: voters near degraded rivers are likely to have a high marginal utility for improvement, and (at least in the context we examine) the proposed policy is likely to yield greater improvement for degraded rivers than for more pristine rivers.

Our empirical strategy follows this reasoning. We model the individual's voting decision in such a way that, controlling for tastes, incomes and tax liabilities, the correlation between *yes* votes and the quality of rivers in the voter's local area can be interpreted as evidence on the local versus nationwide character of river enhancement benefits. Along the way, we introduce a feature that allows us to address the question of whether or not preferences for river restoration depend on the 'quantity' or extent of nearby rivers that would be restored.

Let $i$ index individual voters and their locations and let $j = 0, \ldots, J$ index a set of discrete distance zones relative to voter $i$. Because a river's quality can be different at different points along its flow, we define segments for each river and frame our analysis in terms of quality in

[4] The referendum we examine sought to enhance to 'naturalness' of rivers by altering river beds and embankments toward a more natural condition. Because the term naturalness is somewhat awkward, we often use 'quality' as an alternative term and use quality enhancement when referring to the referendum's goal.

these segments. Assume the utility voter *i* enjoys from a given river segment, *k*, depends on the distance zone in which the segment is located. River segment *k* is defined to be in distance zone *j* relative to voter *i* if $d_{ik} \in [\delta_j, \delta_{j+1})$, where $d_{ik}$ is the distance from voter *i* to river segment *k* and the $\delta_j$ are discrete distances indexed in increasing order. We express this utility as follows:

$$U_i = U\big(Q\big(q_{i1}, q_{i2}, \ldots q_{iJ}, w_{i1}, w_{i2}, \ldots, w_{iJ}\big), Z_i, \phi_i\big). \qquad (1)$$

$q_{ij}$ indicates the average quality of river segments in distance zone *j* relative to voter *i* and $w_{ij}$ indicates their abundance; $Z_i$ is *i*'s consumption of a numeraire private good and $\phi_i$ is a preference parameter. The *Q* function, which we simply refer to as (overall) river quality, is assumed to be quasi-concave and non-decreasing in the $q_{ij}$. Its form reflects the strength of preferences for enhancing local versus non-local river segments, the willingness of consumers to trade off quality at different distances and the role of river quantity, or abundance, in voters' valuations of river quality.

The minimum expenditure required for *i* to attain utility level $U_i$, given an existing level of *Q*, is written

$$e_i = e(Q_i, U_i, \phi_i). \qquad (2)$$

Voter *i*'s constant utility willingness to pay for an improvement in quality is given by

$$\begin{aligned} W_i &= e(Q_i^0, U_i^0, \phi_i) - e(Q_i^0 + \Delta Q_i, U_i^0, \phi_i) \\ &= -\int_{Q_i^0}^{Q_i^0 + \Delta Q} \frac{\partial e\big(Q_i, U_i^0, \phi_i\big)}{\partial Q_i} dQ_i. \end{aligned} \qquad (3)$$

The integral is the area under *i*'s constant utility marginal willingness to pay for river quality, between the pre- and post-policy quality levels. It seems plausible that $\partial^2 e / \partial q_{ij} \partial w_{ij} > 0$, i.e., that willingness to pay for an improvement in quality in a given distance zone is greater when rivers are more abundant in that zone. This is ultimately an empirical question, however.

The referendum we examined proposed a general restoration of the canton's rivers toward more natural conditions and imposed associated tax liabilities. We express *i*'s net-of-tax willingness to pay for a discrete change in *Q*, accompanied by a discrete change tax obligation, as $N_i \equiv W\big(Q_i^0, \Delta Q_i, U_i^0, \phi_i\big) - \Delta T_i$. Because pre-policy utility is increasing in disposable income, $I_i^d \equiv I_i - T_i$, we include disposable income in place of $U_i^0$ in empirical specifications. Person *i* will vote *yes* on the proposed policy if

$$N_i \equiv W\big(Q_i^0, \Delta Q_i, I_i^d, \phi_i\big) - \Delta T_i \geq 0 \qquad (4)$$

and will vote *no* otherwise. For simplicity we assume indifferent voters vote *yes*. We expect person *i*'s net-of-tax willingness to pay for a marginal enhancement in river quality to be decreasing in initial river quality due to diminishing marginal willingness to pay, increasing in the anticipated change in quality, and decreasing in the anticipated tax increase $\Delta T_i$. Income will have a positive effect if river quality is a normal good.

We adopt a linear specification for willingness to pay $W_i = \beta_0 - \beta_1 Q_i^0 + \beta_2 \Delta Q_i + \beta_3 I_i^d + \beta_4 \phi_i$. We assume the revenue source is an income tax, specify a linear tax schedule, $T_i = \tau_0 + \tau_1 I_i^d$, and assume the project's financing comes from an increase in the marginal tax rate $\tau_1$.[5] Voter *i*'s tax obligation from the policy is therefore $\Delta T_i = \Delta \tau_1 I_i^d$. Substituting these terms into (4), *i* will vote *yes* if

$$N_i \equiv \beta_0 - \beta_1 Q_i^0 + \beta_2 \Delta Q_i + \beta_4 \phi_i + (\beta_3 - \Delta \tau_1) I_i^d \geq 0 . \quad (5)$$

The parameters $\beta_1$ and $\beta_2$ are positive and $\beta_3$ is positive if river quality is a normal good. The term $\beta_3 - \Delta \tau_1$ could be positive or negative depending on whether marginal benefits progress more or less rapidly with income than tax liabilities.

We can now disaggregate $Q$ to specify how votes reflect the spatial character of preferences for river quality. We develop our approach in terms of three distance zones, $j$ = 0, 1, 2; extensions to additional zones is straightforward. Zones 0 and 1 are centered on the voter and are relatively small, while zone 2 encompasses the remainder of the country.

We consider alternative specifications for $Q$ in order to examine the question of whether or not river quantity matters to voters. Our basic specification postulates that voters care only about the quality of whatever rivers happen to exist in a given zone, independent of abundance. This implies:

$$Q_i = \alpha_0 q_{i0} + \alpha_1 q_{i1} + \alpha_2 q_{i2} \cong \alpha_0 q_{i0} + \alpha_1 q_{i1} + \alpha_2 q_N \quad (6)$$

where $q_N$ is average river quality nationwide. The approximation follows from the small size of zones 0 and 1 relative to the nation.

The specification in (6) hypothesizes that voters care only about the quality of rivers in various distance zones, irrespective of whether rivers are abundant or scarce in those zones. We also consider specifications in which voter preferences for river enhancement in various distance zones are hypothesized to depend on the abundance of rivers in those zones. While the question of whether or not quantity matters to voters has only a slight affect on the empirical specification, the policy implications of a definite finding one way or the other are potentially substantial.

A finding that $\alpha_0 = \alpha_1 = 0$ implies that river quality is a nationwide public good because voters care only about raising the average quality of rivers in the nation and receive no additional benefit from having river enhancement occur locally. Alternatively, a finding that the local quality coefficients are positive and diminishing with distance would imply that river quality is a local public good. In either case the nationwide average quality term is part of the constant and its coefficient cannot be identified.

Regarding $\Delta Q_i$, voters in the referendum we examine expected the greatest enhancements to occur on the most degraded river segments. We capture this by specifying $\Delta q_{ij} = \lambda(q^* - q_{ij}) \forall i, j$, where $\lambda \in [0,1]$. In words, we assume that voters expected

[5] If the tax is linear in before-tax income it can also be expressed as a linear function of disposable income, which simplifies the notation.

all rivers to be improved toward a common quality target $q^*$ and believed the degree of improvement would be proportional to the initial quality gap.

Combining equations (5), (6) and the expression for $\Delta q_{ij}$, the criterion for individual *i* to vote *yes* is

$$N_i = const. - \gamma\alpha_0 q_{i0} - \gamma\alpha_1 q_{i1} + (\beta_3 - \Delta\tau_1) I_i^d + \beta_4 \phi_i \geq 0, \tag{7}$$

where $\gamma \equiv (\beta_1 + \beta_2 \lambda)$ and terms that do not vary across voters have been combined into a single constant.

To move from a criterion for the individual voting decision, which we do not observe, to the voting proportion in a community, which we do observe, we treat $N_i$ as a random variable with fixed variance and a mean that depends on the community's mean attributes, $\bar{I}_m^d$ and $\bar{\phi}_m$ where the index *m* indicates the community to which *i* belongs. Recalling that the river quality variables $q_{i0}$ and $q_{i1}$ are identical for all individuals in a given community, (7) can be written

$$N_i = const. - \gamma\alpha_0 q_{m0} - \gamma\alpha_1 q_{m1} + (\beta_3 - \Delta\tau_1) \bar{I}_m^d + \beta_4 \bar{\phi}_m + \varepsilon_i . \tag{8}$$

We assume $\varepsilon_i$ is symmetrically distributed with $E(\varepsilon_i) = 0$, $Var(\varepsilon_i) = \sigma^2$.

The probability of observing a *yes* vote in community *m* is now

$$\Pr(yes) = F[const. - \gamma\alpha_0 q_{m0} - \gamma\alpha_1 q_{m1} + (\beta_3 - \Delta\tau_1) \bar{I}_m^d + \beta_4 \bar{\phi}_m]. \tag{9}$$

$F$ is the cumulative distribution function for $\varepsilon_i$. Specifications in which quantity is hypothesized to matter include variables for river abundance in various distance zones as separate regressors. We consider both the uniform and the logistic cdf, which lead to linear probability and logistic regression models, respectively.

To summarize, equation (9) implies that the proportion voting *yes* in a given community depends on the community's average disposable income and preference attributes and on pre-policy levels of river quality in two distance zones. We anticipate $\alpha_0 \geq \alpha_1 \geq 0$. If the estimates satisfy this relationship with strict inequalities, river quality is a local public good to some degree and the coefficients indicate the rate at which benefits decline with distance. If these coefficients are both zero then votes are uncorrelated with local river quality and river quality appears to be a national public good. The role of quantity in voter preferences is addressed by considering specifications that include river abundance in different distance zones.

## 4. Empirical analysis

*The river restoration initiative in the Swiss canton of Bern*

In November1997 the citizens of the Swiss canton of Bern were called to vote on a proposal to establish a cantonal fund for river restoration.[6] The objective was to restore near-natural river environments (beds and embankments) with native flora and fauna and enhanced aesthetic and recreational value. The initiative demanded that 10 percent of the cantonal revenues from water licences, about 3 million SFR per year, are allocated to a fund for river restoration projects in the canton of Bern. The initiative explicitly stated that water fees would not be increased. This fact was also highlighted in the official voter information. The increase of expenditures for river restoration would therefore have to be balanced by a corresponding increase of the revenues generated through direct taxes on income. The total percentage of yes votes among valid votes was 54.1 percent. The popular initiative thus prevailed in the vote (Canton of Bern 1997).

Based on the articles published in the local newspaper *Berner Zeitung*, the opponents did not openly question the need for river restoration but argued that the proposed fund would restrict the budgetary authority of the cantonal parliament and executive in financially difficult times. Proponents were conservation organizations, the cantonal and local anglers' associations and representatives of the construction industry.

*Definition of variables*

The voting data we examine are aggregate vote proportions in 366 municipalities (YESPROP) of the canton of Bern, reported in the canton's voting protocols (Canton of Bern 1997). These municipalities, the smallest units of local government in Switzerland, vary in population from less than 100 to over 100,000 (City of Bern.)

Information describing the eco-morphological status of the rivers in the study area at the time of the referendum was available from a detailed geo-referenced dataset of the Water and Soil Protection Laboratory of the Canton of Bern (WSPL 2003). This dataset describes the status of each river segment, which was field-recorded following procedures defined by the Federal Office of Environment (FOEFL 1999). The dataset also contains a variable "naturalness" ranging from 1 (for underground river channel) to 5 (for "natural or near-natural status"), which we use as an indicator of quality. Naturalness is defined based on a scoring of several eco-morphological attributes, including variability of river width, extent and type of bed stabilization, extent and type of embankment stabilization, width of riparian zone and vegetation cover. The attribute data are linked to a digital vector map of the rivers and the vector dataset of the rivers was linked with a vector map containing municipal boundaries and town centers (Swisstopo 1999). A comprehensive documentation of the dataset is available in WSPL (2003) and FOEFL (1999). Variables $q_j$ ($NAT_j$) for the weighted mean naturalness and $w_j$ ($METER_j$) for the summed length (in meters) of the river segments within a given distance band $j$ from the municipal centers (and situated within the canton of Bern) were derived using standard tools in ArcGIS 9.0. We constructed these variables for the distance bands $j$ of 0–0.5 km, 0.5–1 km, 1–2 km and 2–5 km.

[6] Schläpfer and Witzig (2006) provide a descriptive empirical analysis of voting results and an extended discussion of the politics leading up to the vote.

Mean income per taxpayer (INC_MEAN) for municipalities was computed from the total of reported net incomes in the tax period 1997/1998 and the number of taxpayers ("normal cases and special cases with a direct federal tax burden") as reported in the federal tax administration's publication for the tax period 1999/2000 (FTA 2004).

We examined several additional explanatory variables to account for possible variations in voter preferences linked to local socioeconomic, cultural and hydrological factors. The rationale for each of these is explained as results are presented. Population density (POPDENS) in the voting districts (municipalities) was derived from the 1990 federal census data (Federal Office of Statistics 2006) and land surface data from the Canton of Bern Office for Municipalities and Spatial Planning (OMSP) (2002). The proportion of the population employed in the construction sector (CONPOP90) is based on data from the 1990 federal census (Federal Office of Statistics 2006). Language dummies $LANG_k$ (for Germanic, French and mixed language and cultural background) and region dummies JURA, PREALPS and ALPS (for four main geographic regions with Swiss Plateau as the reference) are based on data from the Office of Municipalities and Spatial Planning, Canton of Bern (OMSP 2002). A dummy variable DAMAGE, for the occurrence of water related damage by floods and landslides, was coded based on the flood and landslide database of the Federal Research Institute WSL, Birmensdorf (Hegg et al. 2000). This variable indicates whether a municipality had been a "main affected municipality" of a flood or landslide at least once during the ten-year period prior to the referendum. Finally, district dummies were coded for the twenty-six administrative districts of the canton of Bern. Descriptive statistics for the independent variables are presented in Table 1.

For 11small municipalities, vote totals were reported only for groups of communities, so votes cast could not be spatially related to river attributes precisely. A similar problem arises for a few 'fragmented' municipalities comprised of non-contiguous land areas, each with their own center. We chose to drop those voting districts, yielding a dataset with 366 observations.

*Estimation*

We used the proportion of yes votes (YESPROP) as our dependent variable in linear probability regressions and the log odds of YESPROP in logit regressions. We found that the marginal effects from logit models are essentially identical to coefficients from linear probability models, and hence we only report the latter for brevity.[7] We begin by examining voting responses to variations in local river quality and report results from the simplest specification our model would support. The basic model is then extended to allow for two distance zones. Parallel models that allow for voter responses to variations in the quantity or extent of local rivers are estimated next. In all of the summary statistics, simple correlations and regressions reported in the following, observations from each municipality were weighted by the municipality's total vote. The results therefore depict the voting choice of an average or typical voter, rather than the average result from a municipality of indeterminate size. All models are estimated with robust standard errors (Huber/White).

[7] Because the voting responses are grouped the linear probability model is not subject to the problem of making predictions outside the unit interval in the data we examine. Logit results are available on request.

*Results*

Table 1 provides variable names and descriptive statistics. Clearly, there is wide variation across communities in both river naturalness (quality) and river meters (quantity) in all distance zones. The variables we include as controls also vary widely across the sample. One very small community was unanimous in voting against the measure; its *yes* vote proportion was arbitrarily set equal to .01 to compute LOGITYES for estimating logit models.

Table 2 reports simple correlations for the variables of primary interest, the proportion voting yes and naturalness levels in various distance bands. Naturalness in all distance zones has a strong negative correlation with yes votes, which agrees with the local public good hypothesis. Naturalness in different distance zones are also strongly correlated with one another, particularly for zones within a 2 km radius of municipal centers, which makes it difficult **to** resolve the separate effects of naturalness in different zones on yes votes. As a consequence, we generally report results only for a single aggregated zone, 0-5 km, or for two zones, 0-2 km and 2-5 km.

In addition to local naturalness and income, which our model clearly indicates belong in the specification, we consider a set of conditioning variables to capture variations in tastes or local environmental conditions. Rural voters may derive different amenities from rivers than urban voters, which motivates us to include population density as a determinant of voter support. Voter support may well be linked to variations in the physical environment, which we represent with dummy variables for three of the four geographic regions in the canton, labelled JURA, ALPS and PREALPS. Language differences reflect cultural factors related to preferences, and we capture these with dummy variables for regions in which French versus German predominate (regions in which the two are found together is the default). The proposed river enhancement was expected to cause construction activity and was supported by construction industry groups; we allow for this effect by including employment in the construction industry relative to population. Because a past history of flooding may cause a community to regard the local river as a force to be tamed rather than an object of preservation, we include the dummy variable include DAMAGE, which indicates a history of flood damage. Finally, spatial heterogeneity that we do not observe may affect support in ways not captured by our controls. We control for this possibility by including dummy variables for 25 of the 26 voting districts in the canton. Overall, we find population density and the district dummies to be significant in all specifications. Flood damage and construction employment are never significant and excluding them has no appreciable effect on other estimates. The language and regional dummies are significant in some specifications, but not in others and again our key coefficients show little sensitivity to their presence. All of the conditioning variables are retained in subsequent models, but the coefficients of variables that are of little interest (topographic regions, language dummies, construction employment and prior flood damage) are not reported to avoid cluttering the tables.

Table 3 explores our basic specification and two variations: the variations examine how finely we can detect the effect of local naturalness in different distance zones and show how the inclusion of regional district dummies affects the results of interest. In all four cases the local naturalness effect is negative and significant, which agrees with the local public good hypothesis: voters in regions where rivers are relatively pristine are less likely to support a canton-wide restoration program than voters in regions where the rivers are more degraded. The second part of the local public goods hypothesis, that the link to local naturalness should diminish with distance from the location of voters, is confirmed for the point estimates that include district fixed effects (column 4), but not for the estimates that exclude fixed effects (column 2). Because the fixed effects are highly significant we are inclined to place greater trust in these estimates (column 4), and hence take this as further evidence that the local component of river restoration benefits is important.[8] We attempted to get greater resolution on the relationship between votes and the spatial pattern of naturalness by breaking down the 0-2 km band into smaller sub-bands. We could not reject the hypothesis that the coefficients for these smaller bands are equal, however, so no finer detail on the spatial link between support and naturalness can be established. Notice also that the effect of income is generally insignificant. In cases where it approaches significance, the effect is positive, indicating that benefits progress more rapidly with income than tax liabilities, but the most consistent finding is that voters were not aligned in terms of income level in supporting or opposing this referendum.

We argued earlier that voters in rural areas may derive different amenities from, and have different attitudes to, rivers than voters in rural areas. This motivated us to include population density as a control, and it turned out to be highly significant. Including density as an independent variable is only appropriate if the difference operates through a simple shift in support regardless of the local naturalness level. Intuitively, it is plausible that any such effect would operate through different responses to local naturalness by rural versus urban voters. For a more urbanized population, the local river may be a focal point of commercial, leisure and tourist activity; in rural areas the local river may be more integrated into the natural environment. We test for this possibility by amending the models of columns 3 and 4 in Table 3 to allow for different responses in different size municipalities. The total vote was used to define large versus small municipalities, with the dividing line set at 1000. Results are shown in Table 4. When naturalness in a single distance band is included, local river naturalness is found to matter more in small municipalities than in large municipalities, and the difference is significant. Results for large versus small municipalities when we include naturalness in two distance bands are shown in column 2; the naturalness coefficients for the two distance bands are not significantly different from one another for either small or large municipalities.

As explained earlier, the referendum proposed to restore rivers throughout the canton and the amount of restoration anticipated in any local area should, arguably, be positively related to local river abundance. We examined the possibility that this would affect voting choices by adding variables for meters of river segment in each distance band to the models in Table 4. The results, not reported here, are easily summarized. The coefficients of naturalness remain largely unaltered. The coefficients for meters of river segment in each distance band are generally negative—that is, greater abundance of local rivers inclines voters against the river restoration program. The negative quantity effect is insignificant in the model with two distance bands, i.e., models corresponding to columns 2 and 4 in Table 3 and column 2 in Table 4; it is significant in models with a single distance band. A significant positive response to local abundance is never observed.

*Discussion*

Our key findings are two-fold. First, the benefits from canton-wide river restoration have a strong local component. Empirically, local voter support is lower when local rivers are relatively pristine. This observation is consistent with the local public good interpretation if one accepts a simple diminishing marginal utility argument and the plausible voter expectation

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[8] We cannot reject the hypothesis that the column 4 naturalness coefficients for the two distance bands are equal.

that relatively pristine rivers faced little possibility of enhancement. The related prediction that the effect of naturalness on voter support should diminish with distance away from municipal centers was supported in estimates for large municipalities and in estimates that specify a common effect for all municipalities; it was not supported for small municipalities. Second, voter support is not positively related to the abundance of local river segments, which we hypothesized is related to the likely extent of local public good improvement. The following discussion addresses both findings.

On the first point, our estimates indicate that the local component of benefits is significant statistically, but provide no information on the relative magnitudes of local versus canton-wide benefits. We can, however, determine how important local river conditions were for the referendum's passage. We do this by forming the predicted yes vote in each municipality using actual community characteristics, but replacing the actual NAT0_5 value for each community with the value "5". This corresponds to a counter factual situation in which each voter's local rivers have been set to pristine conditions *ex ante*, but river conditions elsewhere in the canton remain at actual values. The intent is to simulate the voting outcome that would have occurred if voters expected the referendum to have no effect on local river quality but to enhance quality elsewhere. Using the estimated coefficients from Table 4, columns 1 and 2, we obtain the counter factual voting results shown in Table 5. Absent local enhancement benefits, the referendum would have failed canton-wide, with only 46% voting yes; the actual yes vote was 54%. Further, only 8 municipalities would have voted to approve the measure in the counter factual situation, whereas 197 actually voted in favour of it.

The results can be used to provide rough empirical guidance for assigning funding responsibilities between municipalities and the canton. Following the logic of fiscal federalism, the findings suggest that a system of matching grants – in which cantonal support is conditioned on a contribution by the local governments – would promote a provision of the public good that is grounded in voter preferences.

The second point we discuss is more a puzzle than a result: voter support for canton-wide river restoration is not positively related to the local abundance of rivers. This is puzzling because the extent of local enhancement that would result from the canton-wide program should be positively related to the abundance of river segments in the voter's local area. The finding that votes are related to the *quality* of local rivers, and in a direction that agrees with predictions, only makes the insensitivity to *quantity* all the more surprising. One explanation for a complete insensitivity to quantity is that voters regard the good offered as "a local environment with high quality rivers" rather than a specific amount of river enhancement.[9] This might be motivated by a sense of 'stewardship'—a wish to enhance or protect the quality of any rivers found in the local area, regardless of abundance. Similar non-responsiveness to quantity or scope has been reported in CV studies on natural resource damage assessment (Boyle et al. 1994; McFadden 1994).[10]

Another interpretation is based on recent findings from political science. Political scientists have produced evidence that voters are badly informed about the content of proposed policies. Nevertheless, poorly informed voters, even when facing complex ballot issues, often

[9] Kolstad (2000, p. 371) suggests this explanation for the anomalous CV results cited next.
[10] Rollins and Lyke (1998) argue that insensitivity of existence values to scope can be rationalized if one allows marginal existence values to be diminishing in a set of natural assets being considered for protection. This argument seems not to apply in the present circumstance, however, as the values involved are arguably use values. Rivers in most of the communities examined are a prominent part of the local environment and voters presumably 'visit', or interact with, them regularly. Indeed, the frequency with which an average resident does interact, and the use values enjoyed, should be positively related to the density of local rivers.

can make optimizing voting choices by following cues or "short cuts" revealed by the political debate (Lupia 1994, Lupia and Matsusaka 2004). Cues revealed by the identity of groups who support and oppose a given ballot measure can be particularly powerful in this regard. This finding may reconcile the consistent explanatory patterns usually found in the analysis of voting behavior with the frequent "anomalies" in survey-based preference elicitation. If the political scientists' interpretation is correct, economic preferences will *consistently* reflect the local condition of a public good only at those spatial scales at which an informed public debate has taken place. In the present case, the requirement for voter preferences to consistently reflect river conditions within a radius of 5 km of municipal centers would be an informed community-level debate. However, according to our media analysis and personal communications, the debate between proponents and opponents of the initiative took place largely at the cantonal level. In this light, it is perhaps not surprising to find that local votes did not consistently reflect the local abundance of rivers, and hence the *quantity* of enhancement likely to occur locally.[11] The same reasoning would seem to predict a corresponding insensitivity to *quality* differences, however, which is contrary to what we observe.

A caveat regards the observational nature of the data. Although we controlled for variables such as income, population density (to account for the urban-rural difference in preferences), and regional heterogeneity, we cannot rule out the possibility that the effect of river quality is due to another correlated variable. The same caveat applies to the missing quantity effect discussed above. If, for instance, river quantity happened to be positively related to some aspect of the urban-rural gradient that our model did not fully capture, then that gradient might have offset any positive effect of river quantity in the models. Furthermore, we cannot rule out the possibility that some voters interpreted the locally perceived river quality as the canton-wide average quality. For those voters, the observed effect of local river quality would then not necessarily imply a local benefit component. On the other hand, one might expect that some environmentalist voters might choose to live near pristine rivers. In that case, the effect of local river quality on the remaining voters' decisions would be even stronger than our estimates indicate. From a financing perspective, however, these issues are perhaps not disturbing. Regardless of causality, the populations living near more degraded rivers were more supportive of and hence more willing to pay for the restoration programme.

## 5. Conclusions

For several reasons, referendum voting is a valuable source of preference information about public goods. In contrast to the hypothetical votes in surveys, the relevant geographic extent of the public good improvement and the distribution of costs are clearly and credibly defined. Moreover, the specific proposition has been the subject of political debate in which the voters are exposed to a variety of arguments from both sides. Our findings indicate that canton-wide (or state-wide) referendum voting on public good provision offers a valuable opportunity for analyzing how far the localized benefits of public goods extend, at least qualitatively. Due to the wide acceptance of referendum voting as a preference elicitation mechanism, such results can provide a useful starting point for debates about the appropriate assignment of responsibilities between multiple levels of government in federal systems.

[11] The voter preferences for the "local component" of the public good may thus be similar in nature to the stated preferences of an isolated survey respondent.

However, the finding that support for river enhancement is independent of the extent of rivers in the voter's locality raises questions about how heavily one can lean on these results for policy purposes. The possibility that this behavior reflects a stewardship motive is clearly speculative without further evidence; if true the implications for policy and the application of benefit-cost tests would be substantial. Alternatively, the lack of scope sensitivity may stem from the limited "spatial resolution" of the (canton-level) pre-referendum debate, which in turn caused preferences to be insensitive to the quantity of public good improvement. If so, the spatial voting patterns we interpret as evidence on preferences may actually be a consequence of the spatial scale of the political processes that voters relied upon for information to inform their voting choices.

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Table 1. Variable definitions and descriptive statistics[a]

| Name | Description | N | Mean | SD | Min | Max |
|---|---|---|---|---|---|---|
| YESPROP | Proportion yes votes | 366 | 0.5413 | 0.074 | 0 | 0.87 |
| NAT0_05 | Mean naturalness in 0-.5 km. band | 320 | 1.90 | 0.931 | 1 | 5 |
| NAT05_1 | Mean naturalness in .5-1 km. band | 354 | 2.52 | 1.043 | 1 | 5 |
| NAT1_2 | Mean naturalness in 1-2 km. band | 365 | 2.77 | 0.794 | 1.44 | 4.93 |
| NAT2_5 | Mean naturalness in2-5 km. band | 363 | 3.12 | 0.480 | 2.14 | 5 |
| METER05 | River meters in 0.5 km. zone | 320 | 1513 | 909 | 25 | 6292 |
| METER05_1 | River meters in 0.5-1.0 km. zone | 320 | 3724 | 1948 | 364 | 12690 |
| METER1_2 | River meters in 1.0-2.0 km. zone | 354 | 10719 | 5558 | 430 | 31356 |
| METER2_5 | River meters in 2.0-5.0 km. zone | 365 | 673195 | 28275 | 1354 | 173815 |
| INC_MEAN | Mean income (1997, in SFR) | 366 | 58.18 | 11.29 | 32.34 | 95.06 |
| POPDENS | Population density | 366 | 11.00 | 10.60 | 0.010 | 48.08 |
| CONPOP90 | Constr. employm't./ pop. (1990) | 366 | 0.0420 | 0.012 | 0 | 0.118 |
| LANG0 | French language | 366 | 0.0501 | 0.218 | 0 | 1 |
| LANG1 | German language | 366 | 0.9091 | 0.288 | 0 | 1 |
| JURA | Region | 366 | 0.1087 | 0.312 | 0 | 1 |
| PREALPS | Region | 366 | 0.1363 | 0.344 | 0 | 1 |
| ALPS | Region | 366 | 0.0740 | 0.262 | 0 | 1 |
| DAMAGE | Prior flood damage | 366 | 0.4757 | 0.500 | 0 | 1 |

[a] Observations are weighted by the total vote in each municipality.

Table 2. Simple correlations

| Variable | YESPROP | NAT0_05 | NAT05_1 | NAT1_2 | NAT0_2 |
|---|---|---|---|---|---|
| NAT0_05 | -0.4011 | | | | |
| NAT05_1 | -0.4059 | 0.5512 | | | |
| NAT1_2 | -0.4430 | 0.6146 | 0.7274 | | |
| NAT0_2 | -0.4511 | 0.6664 | 0.8465 | 0.9672 | |
| NAT2_5 | -0.4148 | 0.5249 | 0.3621 | 0.5906 | 0.5730 |

Note: All correlations are significant at .00005 or better. Observations are weighted by total vote.

Table 3. Basic specification: Testing for the effect of local naturalness

| Variable | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| NAT0_5 | -.0369<br>(2.68) | --- | -.0300<br>(1.87) | --- |
| NAT0_2 | --- | -.0145<br>(1.85) | --- | -.0238<br>(2.65) |
| NAT2_5 | --- | -.0233<br>(1.38) | --- | -.0071<br>(0.44) |
| INC_MEAN | -.0001<br>(0.18) | .0001<br>(0.22) | .0002<br>(0.35) | .0006<br>(1.27) |
| POPDENS | .0020<br>(4.09) | .0016<br>(2.75) | .0022<br>(3.17) | .0015<br>(2.13) |
| District dummies | No | No | Yes | Yes |
| Prob>*F* | --- | .0009 | --- | .0039 |
| N | 366 | 362 | 366 | 362 |
| $R^2$ | .38 | .39 | .51 | .54 |

Note: t-statistics in parentheses. Observations are weighted by total vote. The *F* tests reported are for the null hypothesis that the coefficients of naturalness variables in two distance bands are both zero.

Table 4. Testing for different naturalness effects in large versus small municipalities

| Variable | (1) | (2) |
| --- | --- | --- |
| NAT0_5 Small | -.0507<br>(3.35) | --- |
| NAT0_5 Large | -.0345<br>(2.41) | --- |
| NAT0_2 Small | --- | -.0146<br>(1.28) |
| NAT2_5 Small | --- | -.0297<br>(1.71) |
| NAT0_2 Large | --- | -.0264<br>(2.10) |
| NAT2_5 Large | --- | -.0035<br>(0.16) |
| INC_MEAN | 7.64e-06<br>(0.02) | .0007<br>(1.24) |
| POPDENS | .0011<br>(1.68) | .0005<br>(0.77) |
| District dummies | Yes | Yes |
| N | 366 | 362 |
| $R^2$ | .55 | .58 |

Note: t-statistics are in parentheses. There is a significant difference in naturalness for large versus small municipalities in col. 1. Naturalness coefficients in the two distance bands examined in col. 2 are jointly significant at 1% for small municipalities and at 0.1% for large municipalities. For the col. 2 estimates, the hypothesis of equal coefficients for naturalness in different distance bands cannot be rejected for either large or small municipalities.

Table 5. Voting results in counter factual simulations

| | Counter factual | | |
|---|---|---|---|
| | Table 4, col. 1 | Table 4, col. 2 | Actual |
| Popular ‘yes’ vote, canton-wide | 46.12% | 46.28% | 54.13% |
| Number of municipalities approving | 8 | 8 | 197 |