A prequel to using the benefit function to value non-market goods: identifying the implicit price of open space conservation

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1. Motivation

Open space conservation has been increasingly used as an integral part of smart growth planning. Well-managed open space programs provide opportunities for recreation, to preserve important environmental and ecological functions and to enhance community quality of life. According to the Trust for Public Land, voters across the United States generated a total of $11 billion for land conservation between 2008 and 2010. A more difficult question, however, concerns measuring the benefits of open space conservation to evaluate the efficiency of these policies. The welfare impacts of open space will have implications for the optimal amount of open space conservation and the location of this conservation.

The purpose of this paper is to estimate the welfare implications of different types of open space conservation for households living in Door County, Wisconsin. Door County's plentiful open space and scenic beauty make it a popular tourist destination. Door County is also home to many ecosystems ranked of global importance that host rare species. This has led to many conservation efforts in Door County as policies that balance economic growth and tourism with conservation goals become increasingly important to protect this unique county from overdevelopment, rising land prices and continued recreational demand.

The welfare effects of open space conservation in Door County will be measured by marginal willingness to pay (MWTP) estimates from a first-stage hedonic estimation. The first-stage hedonic provides estimates of the marginal implicit prices of open space which will equal the MWTP in equilibrium. It is well-noted that the first-stage hedonic cannot provide welfare estimates for non-marginal changes in quantity or changes that cause the equilibrium to shift. In the context of this study, the first-stage hedonic would allow estimation of the MWTP for different types of open space and allow policy simulations that only marginally change the amount of open space. Given the history of open space conservation in Door County, it is likely that policy-makers would only have to consider the welfare effects of marginal changes in open space. Therefore a well-identified first-stage hedonic estimation should provide policy relevant measures of the benefits of different types of open space.

Furthermore, the first-stage hedonic can provide estimates of the complementarity or substitutability of consumption of open space and private lot sizes. The relationship between distance to open space and private lot sizes will have policy implications for the landscape around open space and also the welfare of nearby households. If open space and private land are substitutes then landowners would trade-off private land for public land and small landowners would benefit more from open space policies. If open space and private land are complements then large parcels near open space will provide more benefit than smaller parcels and large landowners would benefit more from open space conservation. However, a welfare measure that specifies preferences will be needed to estimate the distributional effects of open space conservation. Since Door County has a large number of wealthy absentee landowners, the distributional effects of open space may have important implications. Also if welfare measures are to be included in the optimal location of open space then welfare measures need to extend beyond the equilibrium concept of the first-stage hedonic.

Thus, a first-stage hedonic regression provides estimates of MWTP for open space conservation for landowners in Door County in equilibrium and for marginal changes in open space and provides estimates of the complementarity or substitutability of open space and private lot size. However, moving beyond the first-stage hedonic allows estimation of the distributional effects of open space and estimation of the optimal location and provision of open space. Therefore, the ultimate goal of this study is to use the marginal implicit prices of open space obtained from the first-stage hedonic regression in a benefit function framework extended to nonmarket goods.

The first-step, though, to most nonmarket valuation methods is a well-identified first-stage hedonic regression. Government agencies and nonprofits often systematically choose to locate open space in scenic areas. If scenic areas are also more likely to have high property values then the hedonic estimation confounds the effects of open space with the effects of the scenic area. Open space may also be located in wealthier areas or areas closer to wetlands. The Monte Carlo results from Kuminoff et al. (2012) indicate that spatial fixed effects control for much of this omitted variable bias in first-stage hedonic regressions. However, the optimal neighborhoods at which the spatial fixed effects are defined is not clear. Therefore, this paper presents results for various hedonic price functions under different assumptions for the definition of the spatial fixed effects. Also, a panel-data instrumental variables method is illustrated as an alternative method to using spatial fixed effects to control for the endogeneity of open space.

This paper makes several contributions to the hedonic literature. First, a rich dataset composed of property sales, assessed values and various spatial characteristics from 1991-2001 is developed completely from publically-available data. Second, the hedonic results are compared across differing assumptions about the exogeneity of open space conservation. This allows a better understanding of where open space is located and the severity of exogeneity assumptions can be evaluated. Finally, we recognize the importance of special fixed effects in the regression, and explore several methods of accounting for this influence. We find the Hausman-Taylor estimator to be the most effective method of addressing the effect of spatial characteristics in our analysis.

2. Data

2.1 Study Area

This application focuses on Door County, Wisconsin, a peninsula between Green Bay and Lake Michigan that is home to 27,815 year-round residents and 23,966 total housing units (U.S. Census Bureau 2010). Door County's plentiful open-space, scenic beauty and unique physiographic features such as ridges, embayment lakes, dunes and Niagara escarpment make it a popular tourist destination with about 240,000 tourist visits each year (Lamb 1999) and around 35% of homes owned by seasonal residents (US Census Bureau 2010).

Door County is also home to one of Wisconsin's greatest concentrations of rare species such as the Hines Emerald dragonfly, dwarf lake iris and the whooping crane, some of which only live in the region. Therefore open space conservation has played and continues to play an important part of land management especially with increasing land development, skyrocketing land prices and increased recreational pressures. Several organizations (the Wisconsin Department of Natural Resources, the Door County Parks Department, county townships, the Nature Conservancy and Door County Land Trust, and various specialty groups) have invested heavily in open space in Door County, each with slightly different goals.

The Wisconsin Department of Natural Resources (DNR) has identified the Great Lakes shoreline of Door County as being of global importance for ecological preservation and the high quality wetlands in Door County as being of statewide importance. Thus, the Wisconsin DNR has protected five state parks in Door County ("the five jewels in the crown") with the goals of promoting environmental sustainability, nature-based education and outdoor recreation opportunities (Wisconsin State Parks System Strategic Plan 2008-2013). These parks are large wilderness areas that tend to feature various amenities such as campsites, cabins, hiking and biking trails, and beaches and docks.

The Door County Parks Department protects 19 county parks with the stated goals of providing leisure opportunities, building strong families and community pride, promoting physical and emotional health, protecting natural resources and providing economic benefits through tourism and reducing sprawl which not only consumes more land but also requires more tax-supported infrastructure such as roads, sewer lines and police and fire services (Door County Parks and Open Space 2011-2015). Additionally there are 126 town parks and preserves in Door County that are smaller more localized parks.

The Nature Conservancy (TNC) has been working with government agencies, other non-profit organizations, and individuals to preserve the wild places and wildlife in Door County since 1962. TNC has helped protect 5,952 acres in Door County mostly through conservation easements. The Door County Land Trust (DCLT) is another non-profit organization that has helped preserve open space in Door County. Since 1986, the DCLT has helped preserve over 5,000 acres with more recent attention given to 25 special places that showcase the best of Door County's diverse and inspiring landscapes and ecosystems.

Finally, Door County is home to a few specialty parks. Ridges Sanctuary, formed in 1937, is the oldest private nature preserve in Wisconsin. With 1,600 acres of pristine natural area, Ridges is open to the public year-round and provides many services such as naturalist led tours, youth and family programs, a weekly lecture series in the summer and a nature center. Lawrence University in Appleton, Wisconsin owns a specialty park, Björklundn vid Sjön (which is Norwegian for "birch forest by the water") that hosts musical events and provides lodging for rent and the historic Boynton Chapel. And lastly, Crossroads at Big Creek provides a scientific, historical, environmental and learning preserve with a historical village.

2.2 Data Development

The data used for this study were compiled from a variety of sources. Data on the transfer fee for arms-length property transactions, assessed values, and the zip code on the tax bill were collected from the Door County Land Records Search for the years 1991-2011.[1] A transfer fee of thirty cents for every hundred dollars of the sale price is required for all arms-length transactions. Therefore sales prices can be calculated by dividing the transfer fee by $0.003. All transactions are observed in this sample but some transactions (such as inherited properties) are exempt from the fee; the reason for exemption is also observed. The assessed values are composed of structural values, land values and the estimated fair market value (EFMV). The EFMV is the sum of the structural and land value multiplied by an assessment ratio. The assessment ratio attempts to weight assessed values to keep them within ten percent of the full value of property. There is a separate assessment ratio for each township. The assessed value of the structure is included in the hedonic model to control for unobserved housing attributes such as the number of bedrooms, bathrooms, square footage of the house, etc. The zip code on the tax bill was collected to identify seasonal versus permanent residents. Of the properties sold from 1991-2011, only a little over half were owned by permanent residents.

The final dataset contains 28,282 arms-length transactions and assessed values from 1991-2011. The average sale price for homes in Door County over this time period was $119,681 and the average structural value (weighted by the assessment ratio) was $68,853. These prices are deflated by the shelter component of the Consumer Price Index (CPI) to be in terms of 2011 $US (US Bureau of Labor Statistics). The shelter component of the CPI is primarily composed of rent and rental equivalence of primary residence.

Spatial data were calculated from digitized plat maps for Door County (see Zipp et al. working paper). Digital GIS parcel maps exist from 2000-2011. From 1991-1999, paper plat maps were digitized allowing spatial data to be defined for all parcels over the entire time sample. Parcels from the sale data are matched to the spatial data by unique parcel identification numbers (PINs). The PINS are assigned to each parcel by municipality and spatial location. When a parcel subdivides the new (child) parcels are assigned different PINs , however the original (parent) parcel keeps its original PIN. Also if a landowner buys two adjacent parcels they can have the parcels combined under one PIN to avoid being taxed on both parcels.

Once the PINs are matched from the sales data to the spatial data, variables such as the size of the parcel (*lotsize*), the distance to the nearest shore (*shore_dist*), the distance to the nearest city, Green Bay, (*gb_dist*) can be calculated. All distances are calculated as Euclidean distances; this does not take into consideration actual transportation methods. The minimum lot size (*minlot*) was also observed from digitized zoning maps and zoning ordinances. If the minimum lot size affects the option value of how a parcel can be used in the future then it would be expected that this is capitalized into the value of properties such that parcels with larger minimum lot sizes would have lower prices all else equal. Current soil maps from the soil survey geographic (SSURGO) database for Door County, Wisconsin (US Department of Agriculture, Natural Resource Conservation Service) are also included in the analysis. Variables such as the slope (*slope*), flooding frequency (*flood*) and rating for the ability to build structures (*bsmt*) might influence housing values.

[1] I would like to thank Nicholas Hatt for his assistance collecting these data from the Door County Land Records Search, http://pubinfo.co.door.wi.us/LandRecords.

The open space data was developed by working with the Door County Planning Department, Land Information Office and Parks Department, and the Nature Conservancy, ultimately constructing time-indexed GIS layers for all 1,273 parcels of conserved open space (state and local parks and easements) over the period 1991-2011. Open space conservation is not homogeneous in its supply or demand. From the above discussion of the study areas and the previous literature on open space conservation (Lutzenhiser and Netusil 2001, Anderson and West 2003, Acharya and Bennett 2001), five types of open space were identified. These five types are easements, state parks, county and town parks, specialty parks (mostly owned by the University of Wisconsin (UW) system), and parks with playgrounds. Further heterogeneity is identified in the data by observing state, county and town parks that include beaches for swimming or fishing and also county and town parks with playgrounds.

Table 1 in Appendix A provides summary statistics for the variables used in estimation.

3. Empirical Model

3.1 Estimation of the marginal implicit prices

This analysis aims to estimate the marginal implicit prices and thus the marginal willingness to pay (MWTP) for various types of open space with a first-stage hedonic regression of this rich dataset. There are several considerations that need to be addressed when specifying a first-stage hedonic regression. The hedonic hypothesis states that goods are assumed to be valued for their utility-bearing attributes. Houses are assumed to be differentiated production with obvious differences in their attributes but traded in the same market. Therefore housing prices will depend on consumers' preferences for the attributes of the house. A general form of the hedonic price function specifies property sale prices of parcel *i* in municipality *j* at time *t* as a function of attributes:

$$f(P_{ijt}) = f(Distance_{ijt}, Z_{ijt}, W_{ij}, \beta, \alpha, \gamma) + c_{ij} + \nu_t + \mu_{jt} + \varepsilon_{ijt} \quad (1)$$

where $Distance_{ijt}$ is a (5x*N*) matrix of the distance to the closest easement, state park, county or town park, park with a playground and closest specialty park, Z_{ijt} is a matrix of the time-varying and spatially varying variables (minlot, lotsize[2], structural value, condo and the size of the open spaces), W_{ij} is a matrix of the time-invariant, spatially-varying variables (distance to the shore, distance to Green Bay, and the various soil measures). The error component in equation (1) is composed of three terms. First c_{ij} is a vector of parcel-specific unobserved heterogeneity. It is likely that many parcel-specific attributes that affect the price of a property are not included in this model. Second, ν_t is a vector of time-varying but spatially-invariant unobservables such as changes in the mortgage rate, interest rate or various housing bubbles and busts in this 20 year time period. Third, μ_{jt} is a vector of unobserved heterogeneity across

[2] Given how PINs are defined parcels can shrink in size if they are subdivided and they can grow in size if multiple parcels owned by the same owner are consolidated. Around 3,000 of the observed parcels undergo a change in size sometime in the sample.

municipalities and time capturing changes in community amenities such as school systems, tourist amenities, libraries, to name a few. Finally, ε_{ijt} is an independent and identically distributed error term.

Estimation of the marginal implicit prices of different types of open space requires various assumptions about the size of the market, stability over time, the timing of the environmental good or service, the functional form of the hedonic pricing equation, multicollinearity, and omitted variable bias. In this analysis, I assume that there are a reasonable number of consumers who would consider alternative areas in Door County to treat Door County as a single market. I begin with an assumption that any time variation in the hedonic price function can be captured in time fixed effects that shift the intercept but do not affect the slope of the hedonic function. This assumption requires the capitalization of open space into property values to be stable from 1991-2011. The validity of this assumption can be tested and relaxed. I assume that open space is immediately capitalized into the property value and that property owners do not preemptively form expectations about the location of open space and that there is no lag in the capitalization[3].

The functional form of equation (1) is not dictated by theory[4], therefore the robustness of results should be compared across different specifications and the AIC can aid in the choice of functional form. Multicollinearity is often a problem when attributes are correlated. For example, number of bedroom is most likely correlated with the square footage of a home. If different government agencies and non-profits are all trying to protect the same land from development then the distance to the closest county park may be correlated with the distance to the nearest easement. This can be tested for but there is not much to do if multicollinearity is indeed a problem. I could create a composite index for distance to open space, but hopefully the types of open space included in the analysis are distinct enough so that this is not a problem.

Omitted variable bias is one of the most difficult problems to overcome in a first-stage hedonic regression and has received recent attention in the nonmarket valuation literature (Kuminoff et al 2012). It is likely that parcel-specific unobservables are correlated with distance to open space. As noted from the discussion of open space, government agencies and nonprofits systematically choose to locate open space in scenic areas. If scenic areas are also more likely to have high property values then the hedonic estimation confounds the effects of open space with the effects of the scenic area. Open space may also be located in wealthier areas or areas closer to wetlands.

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[3] Every five years, the Door County Planning Department coordinates with other governmental and non-profit organizations to form a strategic plan for the parks and open space of Door County. This plan is publically available and it is possible that landowners can reasonable predict where the addition of open space will be, but the language of the strategic plan is sufficiently vague to make me believe that this is unlikely. Although it might be worthwhile to talk to developers in Door County to make sure that this assumption is valid. It is also possible that there is lag between the open space conservation and the capitalization into land values. These dynamics can be further explored in future research.

[4] Although the functional form of the hedonic price equation is not dictated by theory, some functional forms can be seen as more desirable than others. For example, a linear hedonic price function presumes that the marginal implicit prices of open space are constant for everyone and this is usually considered undesirable (Rosen 1974).

Kuminoff et al (2012) use a Monte Carlo estimation to illustrate the importance of including spatial fixed effects to control for the omitted variable bias. The spatial fixed effects will control for all time-invariant unobserved heterogeneity such as the scenic value of an area. However, spatial and time fixed effects should be interacted to capture any unobserved changes over time such as the income of areas can change over time and so can other community amenities both of which will be correlated with the location of open space conservation (Kuminoff et al 2012).

The most general hedonic price function in this setting is equation (1) where individual parcel-specific fixed effects can control for the time-invariant, spatially varying heterogeneity such as scenery (c_{ij}), year fixed effects can control for time-varying, spatially-invariant heterogeneity such as general economic indicators (ν_t), and municipality fixed effects can be interacted with year fixed effects to control for time- and spatially-varying heterogeneity such as changes in community amenities (μ_{jt}). Specifying individual parcel-specific fixed effects is equivalent to a repeat sales estimation. Repeat sales estimation requires data on multiple sales of the same property and uses the change in the distance of open space and the change in the value of property to estimate marginal implicit prices of open space, controlling for other changes between sales. I observe 6,427 properties that sell more than once from 1991-2011 with an average of a little more than two sales per property. The repeat sales estimation relies completely on variation in the data over time because the spatial location of the property is held fixed. This means that W_{ij} cannot be identified in equation (1) and these time-invariant variables are dropped from the model.

There are two important assumptions for the estimation of a repeat sales hedonic. First, the properties with multiple sales are assumed to be statistically similar to the properties with only one sale. If properties with multiple sales were systematically worse properties (and that is why they are selling more often) then sample selection would need to be controlled for. See Table 2 for a comparison of the descriptive statistics for parcels that only sell once versus multiple-sale parcels. Also Figure 2 presents a map of the spatial location of repeat sale properties versus single sale properties. It appears as though the repeat sale data are a random sample from the entire dataset, although this can be formally tested.

Repeat sales hedonic also assumes that the implicit price of open space is stable over time because the repeat sale estimation only uses variation over time to estimate the implicit price of open space. This may not be true for the twenty year time period included in the sample especially given the recession in 2008. The spatial fixed effects can be redefined to include a larger neighborhood[5], which would allow for tests of the time stability of the implicit price of open space.

The results from Kuminoff et al. (2012) indicate that spatial fixed effects control for much of the omitted variable bias in first-stage hedonic regressions. However, the optimal neighborhoods at which the spatial fixed effects are defined are not clear. Neighborhoods should be defined to be homogeneous areas of land such that there is no variance in where open space is likely to be located. Remember that the spatial fixed effects should control for the unobserved factors that influence the location of open space. Therefore, the neighborhoods should be homogeneous with respect to aspects that influence the location

[5] Or the repeat sales estimation can be estimated for subsets of time periods, for example, before 2008 and after 2008, as long as there is enough variation in the distance to open space over the time periods.

of open space such as scenery, presence of wetlands, and income or political influence. Municipalities are natural neighborhoods that can be easily defined. Door County has nineteen municipalities that vary in their geography, ecology, reputation, wealth level and amenities. The hedonic price equation (1) can be reformulated to include municipal fixed effects instead of parcel-level fixed effects.

$$f(P_{ijt}) = f(Distance_{ijt}, Z_{ijt}, W_{ij}, \beta, \alpha, \gamma) + \sum_{i \in j} c_{ij} + \nu_t + \mu_{jt} + \varepsilon_{ijt} \tag{2}$$

The unobserved heterogeneity within municipalities is not controlled for by the spatial fixed effects ($\sum_{i \in j} c_{ij}$) and thus there is still a potential for omitted variable bias if there is unobserved heterogeneity in the scenic beauty and wealth of areas within municipalities. On the other hand, equation (2) uses variation across time and space to estimate the coefficients of the model. Therefore, the coefficients can be allowed to change over time and the assumption about the stability over time of the implicit prices can be relaxed. The trade-off between the repeat sales and the municipal fixed effect estimation is between assuming stability over time or assuming that municipalities are homogenous with respect to variables that influence the location of open space. Both of these estimations are presented in the results section to compare the implications of the various assumptions.

The spatial fixed effects in equations (1) and (2) are used to control for the endogenous location of open space. Another method that has not been explored much in the hedonic literature is instrumental variable estimation to control for endogeneity. Instruments are typically difficult to find, however, Hausman and Taylor (1981) proposed an instrumental variable estimator that uses only the information within a panel-data model to control for endogeneity. The Hausman-Taylor estimator uses information from both the within-estimator and the between-estimator thus using variation over both time and space. If there are time-varying and time-invariant exogenous and endogenous variables and the econometrician can distinguish between these four types of variables, then the time-varying exogenous variables can serve two functions because of their variation across both space and time: (1) deviations from the mean can be used to produce unbiased estimates of the time-varying exogenous and endogenous variables, (2) using the group means can be used as an instrument for the time-invariant endogenous variables.

Define four types of variables,

$$X_{1it} = K_1 \text{ time-varying exogenous variables,}$$

$$X_{2it} = K_2 \text{ time-varying endogenous variables,}$$

$$W_{1i} = L_1 \text{ time-invariant exogenous variables,}$$

$$W_{2i} = L_2 \text{ time-invariant endogenous variables}$$

Then group mean deviations of the time-varying variables can be used as $(K_1 + K_2)$ instrumental variables, W_{1i} can also serve as a set of L_1 instruments. This leaves a necessity for L_2 additional instruments. The group means for X_{1it} can serve as these remaining instruments. The model is identified if $K_1 \geq L_2$. In this application, the group means or group mean deviations are controlling for the neighborhood effects. For example, if a neighborhood is scenic and thus more likely to have more open space then the group means will reflect this and the mean deviations will represent the distance to open space after the location of open space is controlled for.

Equation (1) is rewritten to include the distinctions between variables and the error term is simplified to only include a parcel-specific fixed effect and an iid error term

$$f(P_{it}) = f(X_{1it}, X_{2it}, W_{1i}, W_{2i}; \beta_1, \beta_2, \alpha_1, \alpha_2) + c_i + \varepsilon_{it} \tag{3}$$

where the exogenous and endogenous variables in this application are defined in the results section. The Hausman-Taylor estimation is done in the following steps.

1. Use the typical fixed effects (within) estimator to obtain unbiased and consistent estimates of $\hat{\beta} = (\widehat{\beta_1}, \widehat{\beta_2})$ and variance-covariance matrix of the within-estimator, σ_ε^2. Then define a vector of group means estimated from the within-group residuals

$$\hat{d}_i = \bar{P}_i - \bar{X}_i \,\hat{\beta} \tag{4}$$

where $\bar{P}_i = \frac{1}{T}\sum_t f(P_{it})$ and $\bar{X}_i = \frac{1}{T}\sum_t f(X_{it})$

2. Expand equation (4)

$$\hat{d}_i = \bar{P}_i - \bar{X}_i \,\hat{\beta} \; = W_i\alpha + c_i + \frac{1}{T}\sum_t \varepsilon_{it} \tag{5}$$

W_{2i} is correlated with c_i necessitating the use of instrumental variables estimate unbiased and consistent coefficients in equation (5). The group means of X_{1it} can be used as K_1 instruments. Therefore as long as $K_1 \geq L_2$, equation (5) can provide unbiased and consistent estimates of α and of the variance-covariance of the error term, $e_{it} = (c_i, \varepsilon_{it})$,

$$\sigma_e^2 = \sigma_c^2 + \frac{\sigma_\varepsilon^2}{T} \tag{6}$$

Using the estimate of σ_ε^2 from step 1,

$$\hat{\sigma}_c^2 = \hat{\sigma}_e^2 - \frac{\hat{\sigma}_\varepsilon^2}{T} \tag{7}$$

3. The estimator is the minimum variance matrix-weighted average of the within and between groups estimators where the weight is defined as

$$\hat{\theta} = 1 - \sqrt{\frac{\hat{\sigma}_\varepsilon^2}{\hat{\sigma}_\varepsilon^2 + T\hat{\sigma}_c^2}} \tag{8}$$

and the variables are transformed by the $\hat{\theta}$- mean deviations

$$Q_{it} = (f(X_{it}), f(W_i))$$

$$Q_{it}^* = Q_{it} - \hat{\theta}\,\overline{Q_{it}} \;\text{ and }\; P_{it}^* = f(P_{it}) - \hat{\theta}\,\overline{f(P_{it})}$$

Then Q_{it}^{*} is regressed on P_{it}^{*}.

By using both the within and between estimators, the Hausman-Taylor estimator is appealing for a first-stage hedonic where the variables of interest are likely to be endogenous.

The results from a repeat sales hedonic, a hedonic with larger spatial fixed effects and a Hausman-Taylor hedonic regression are reported and discussed in the next section.

4. Results

1. Marginal implicit prices of open space and MWTP

From equation (1) the marginal implicit prices of open space are

$$\frac{\partial P_{ijt}}{\partial Distance_{ijt}} = \frac{\left(\beta \cdot \frac{\partial f\left(Distance_{ijt}\right)}{\partial Distance_{ijt}}\right)}{\frac{\partial f\left(P_{ijt}\right)}{\partial Distance_{ijt}}} \qquad (9)$$

For example, in this application, the log-log specification of equation (1) is appealing because the implicit prices of open space are likely to decrease with distance. The AIC of the log-log model was also lower than a semi-log or Box-Cox specification. Therefore, the empirical model[6] is

$$log\left(P_{ijt}\right) = \beta \cdot log\left(Distance_{ijt}\right) + \alpha \cdot \log\left(Z_{ijt}\right) + \gamma \cdot \log\left(W_{ij}\right) + c_{ij} + \nu_t + \mu_{jt} + \varepsilon_{ijt} \qquad (10)$$

And the marginal implicit prices are

$$\frac{\partial P_{ijt}}{\partial Distance_{ijt}} = \beta \cdot \left(\frac{P_{ijt}}{Distance_{ijt}}\right) \qquad (11)$$

Table 4 presents the marginal implicit prices of different types of open space for a half-mile decrease in the distance to open space. In equilibrium the marginal implicit prices will equal the marginal willingness to pay. The positive marginal prices indicate that being closer to that type of park increases property values and a negative marginal price means that it decreases property values.

Table 5: Marginal implicit price of types of open space for a half-mile decrease in distance to open space

	log-log(2)	MUN(2)	MUN(3)	Repeat sales(2)	HT(2)
lneasement	210.05	902.36	1,287.47	839.77	1,313.50
(std. error)	(313.43)	(649.63)	(659.10)	(969.70)	567.38
lnnat_state	190.27	94.82	-5.54	-2,381.04	-1,453.74
(std. error)	(208.84)	(698.36)	(679.36)	(1,275.17)	(717.13)

[6] Note that the dummy variables are not transformed in this model.

lnco_town	1,358.48	881.47	956.72	-3,532.45	-3,745.48
(std. error)	(449.51)	(1,526.60)	(1,536.88)	(1,933.49)	(1,422.93)
lnridges_uw	22.60	15.80	129.48	-175.68	399.65
(std. error)	(84.74)	(189.79)	(206.70)	(487.50)	(398.85)
lnplayground_dist	202.54	171.01	119.61	730.73	764.73
(std. error)	(141.25)	(428.78)	(519.27)	(735.80)	(466.27)
year FE	YES	YES	YES	YES	YES
spatial FE	NO	MUN	MUN	PIN	PIN
spatial * time	NO	NO	MUN* year FE	MUN* year FE	MUN* year FE
AIC	65,103.10	64,610.88	63,394.51	20,750.01	
groups	28,282	18	18	6427	28,282

Notice that the standard errors on the marginal effects for open space are quite large for all the estimators except the Hausman-Taylor. There might not be enough within variation to identify the spatial fixed effects estimators but by using both the within and between variation the Hausman-Taylor is able to get more precise estimates. Notice that the point estimates are fairly similar between MUN(3), Repeat Sales (2) and the HT(2), yet the standard errors are much different based on the assumptions made about the source of variation in the model.

For the Hausman and Taylor estimation the time-varying exogenous variables are minimum lot size, the area of the property, the assessed value of the structure, an indicator if the property is a condo and year fixed effects. The time-varying endogenous variables are the distances to open space (*lneasement, lnnat_state, lnco_town, lnridges_uw, lnplayground_dist, nat_beach, town_beach, town_play*),the area of the open space (*lnarea_ease, lnarea_nat, lnarea_co, lnarea_uw*) and all the interaction terms with the distance to open space. The time-invariant exogenous variables are the distance to the nearest shore, an indicator for which shore (Lake Michigan or Green Bay), the distance to the city of Green Bay, and the soil measures (*lnslope, lnflooding, lnbsmt*).

2. Complementarity question

The sign of the interaction terms between distances to open space and private lot sizes will indicate if these goods are complements, substitutes or separable (no effect). Note that it is the inverse of distance to open space that is "the good" in this study; the closer a property is to open space the more or less it is worth. Therefore, a negative coefficient on the interaction terms means that the closer a property is to open space the more valuable an extra unit of private property. The results in Table 6 indicate that easements and private lot size are consistently complements. There is no consistent finding with the other results.

Table 6: Estimation results for the interaction terms for various estimators[7]

	log-log(2)	MUN(2)	MUN(3)	Repeat sales(2)	Repeat sales(3)	HT(2)
	coef	coef	coef	coef	coef	coef
lnease*lnlotsize	-0.017	-0.017	-0.011	-0.037	-0.032	-0.029
lnnat_state*lnlotsize	0.000	0.006	0.007	-0.035	-0.055	-0.054
lnco_town*lnlotsize	0.018	0.008	0.009	-0.019	-0.026	-0.023
lnridges_uw*lnlotsize	0.017	0.012	0.011	-0.007	0.003	0.007
lnplay*lotsize	-0.002	-0.002	-0.001	0.002	0.002	-0.001
lnarea_ease	-0.068	-0.010	-0.001	-0.162	-0.133	-0.103
lnarea_nat	-0.315	-0.376	-0.331	0.042	0.060	-0.072
lnarea_co	0.058	0.042	0.023	-0.285	-0.392	-0.399
lnarea_uw	-0.080	-0.018	0.077	-0.161	-0.094	0.031
lnease#c.lnarea_ease	0.007	0.000	-0.002	0.017	0.014	0.010
lnnat_state#c.lnarea_nat	0.031	0.037	0.032	-0.004	-0.006	0.007
lnco_town#c.lnarea_co	-0.005	-0.003	-0.002	0.038	0.046	0.048
lnridges_uw#c.lnarea_uw	0.009	0.003	-0.008	0.018	0.011	-0.001
lnplay#lnarea_play	-0.001	0.002	0.001	0.004	0.005	0.008
year FE	YES	YES	YES	YES	YES	YES
spatial FE	NO	MUN	MUN	PIN	PIN	PIN
spatial * time	NO	NO	MUN* year FE	NO	MUN* year FE	MUN* year FE
AIC	65,103.10	64,610.88	63,394.51	24,038.97	20,750.01	
groups	28,282	18	18	6427	6427	28,282

3. Make graphs to show the implicit price of open space against the size of private lots and another graph against the size of open space.

5. Conclusions and future research

1. Use the implicit prices of open space in this paper to extend the benefit function to nonmarket goods. The benefit function is a welfare measure in quantity space therefore it is well-suited to measure the valuation of nonmarket goods where price are not usually available.
2. The welfare estimates provided in this paper allow social planners to maximize welfare through the optimal location of open-space conservation. The locations of open-space that maximize welfare can be compared to the locations that maximize ecological services to provide a richer guide to the optimal location of open-space.
3. DYNAMICS

[7] The remainder of these results are presented in Table 4 in Appendix A. These results are highlighted to answer the complementarity question

Appendix A: Tables and Figures

Table 1: Summary of variables used in estimation

Variable	Description	Mean	Std. Dev	Min	Max
Saleprice*	All arms-length transactions	119,681	97,877.58	99.74	534,708.7
Distance to the closest open space type in feet …					
easement	Easement	7,714.87	6,159.53	0.00	44,980.42
state	State park	14,886.57	11,174.32	0.00	57,763.05
co_town	County or town park	6,425.49	5,294.32	0.00	38,077.66
ridges_uw	Specialty park such as Ridges or other UW owned open space	57,469.56	37,246.43	0.00	197,731.30
playground	Park with a playground	38,345.37	34,861.99	0.00	289,448.70
state_beach	=1 if the closest state park has a beach; =0 otherwise	0.49	0.50	0.00	1.00
town_beach	=1 if the closest county or town park has a beach; =0 otherwise	0.11	0.32	0.00	1.00
town_play	=1 if the closest county or town park has a playground; =0 otherwise	0.13	0.33	0.00	1.00
minlot	Minimum lot size allowed by zoning law	190,203.80	336,442.4	0.00	1,524,600.00
lotsize	The area of the private lot (ft2)	303,257.90	563,033.4	130.00	8,062,956.00
Structural value*	The assessed value of the structure weighted by the assessment ratio**	68,853.05	89,770.47	0.00	2,114,418.00
Condo	=1 if the property is a condo; =0 otherwise	0.18	0.381	0.00	1.00
shore_dist	Distance to the nearest shoreline	201,127.20	94,901.56	0.00	339,857.50
dist_gb	Distance to the city of Green Bay (ft)	2,702,345.00	54,240.44	2,576,834	2,840,891.00
slope	The average slope of the parcel	4.54	3.47	0.00	25.00
flooding		0.28	0.79	0.00	3.00
bsmt		2.57	0.65	0.00	3.00
permanent***	=1 if the resident is a	0.52	0.50	0.00	1.00

	permanent resident, =0 if a seasonal resident				
The size of the closest open space type in square feet …					
area_ease	Size of closest easement(ft2)	1,288,403.00	2,987,592	3,252.00	179,000,000.00
area_state	Size of closest state park (ft2)	4,183,415.00	16,400,000	3,748.00	158,000,000.00
area_town	Size of closest county or town park (ft2)	704,159.30	1,286,201	2,641.00	8,479,445.00
area_uw	Size of closest specialty park (ft2)	35,700,000.00	78,700,000	26,454.00	221,000,000.00
area_play	Size of closest park with a playground (ft2)	504,317.70	311,669.8	2,641.00	877,271.00

*All prices are in 2011 US$

** The assessment ratio attempts to weight assessment values to keep them within ten percent of the full value of property. There is a separate assessment ratio for each township.

*** The seasonal homeowners are identified by the zip code on their tax bill.

Graph 1: The number of housing sales and average sale price from 1991-2011 in Door County, WI

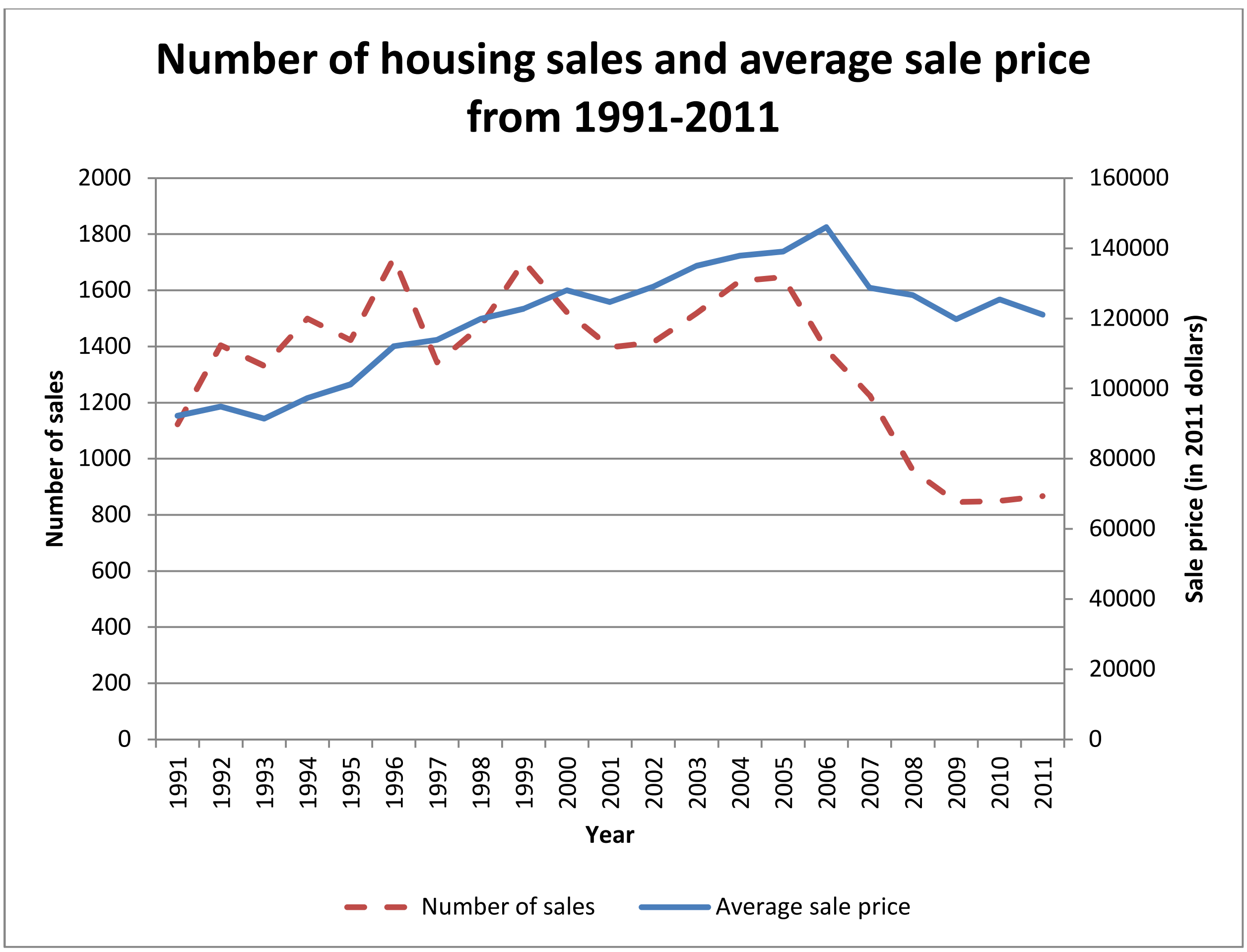

Figure 1: Distribution of housing sales by price, 1991-2011

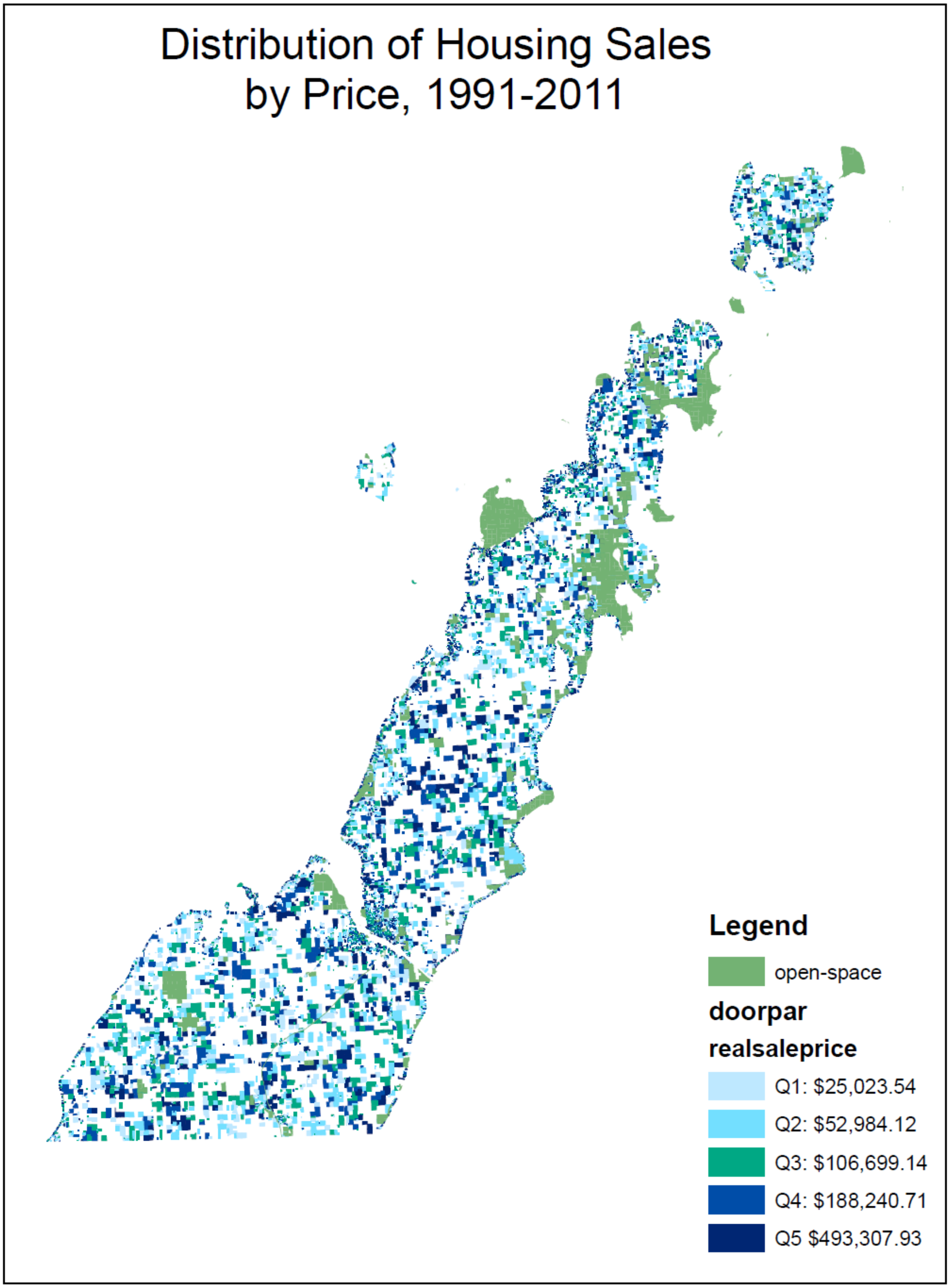

Table 2: Summary of variables included in the full sample and repeated sale sample

Variable	Mean full sample	Mean repeat sale
realsalepr~e	119,681.00	118,621.80
easement	7,714.87	7,820.31
nat_state	14,886.57	15,406.14
co_town	6,425.49	6,676.56
ridges_uw	57,469.56	59,349.44
playground~t	38,345.37	38,252.75
nat_beach	0.49	0.49
town_beach	0.11	0.11
town_play	0.13	0.14
minlot	190,203.80	217,124.20
areaft2cor~t	303,257.90	388,268.50
realimpradj	68,853.05	71,335.62
condo	0.18	0.17
shore_dist	201,127.20	201,755.80
dist_gb	2,702,345.00	2,697,106.00
slope	4.54	4.47
flooding	0.28	0.31
bsmt	2.57	2.59
permanent	0.52	0.54
area_ease	1,288,403.00	1,291,128.00
area_nat	4,183,415.00	3,989,734.00
area_co	704,159.30	751,612.10
area_uw	35,700,000.00	30,400,000.00
area_play	504,317.70	520,311.70

Figure 2: Distribution of repeat sales, 1991-2011

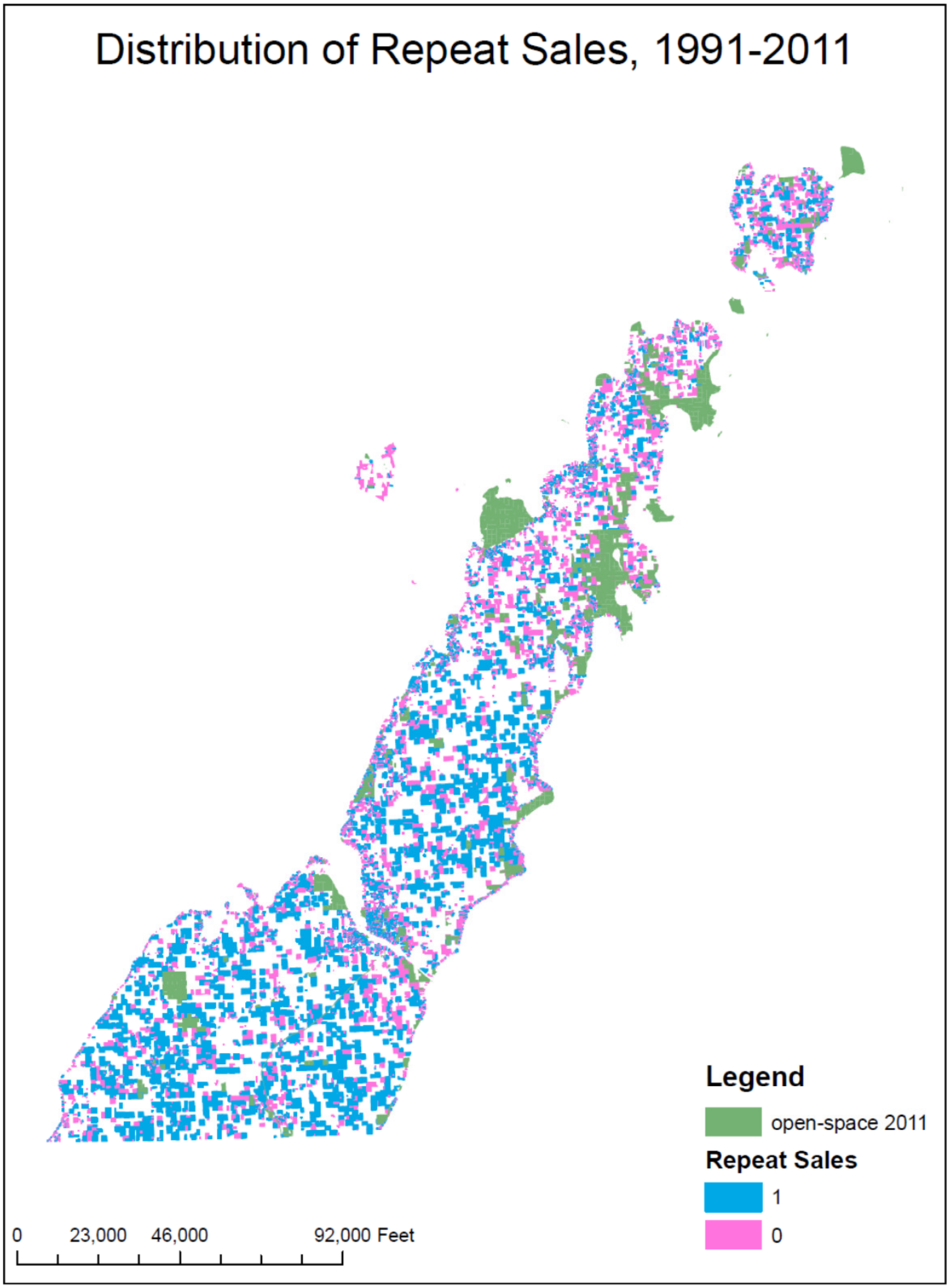

Table 3: Pooled, simple models (log-log) and yellow is significant at <=5% and orange is <=10%

	log-log(1)		MUN(1)		Repeat Sales (1)		HT(1)	
	coef	std error	coef	std error	coef	std error	coef	std error
lneasement	-0.0329	0.0068	-0.0437	0.0177	-0.01312	0.02044	-0.0379	0.0133
lnnat_state	-0.0272	0.0090	-0.0184	0.0242	-0.00423	0.046586	-0.07252	0.03-2
lnco_town	-0.0402	0.0086	-0.0302	0.0280	0.087232	0.035107	0.001353	0.0238
lnridges_uw	0.0221	0.0127	0.0220	0.0260	0.097202	0.036201	0.123607	0.0307
lnplay_dist	-0.0330	0.0164	-0.0211	0.0511	0.037889	0.056913	0.096335	0.0401
nat_beach	0.0919	0.0190	0.0585	0.1264	-0.03608	0.046995	-0.13429	0.0385
town_beach	0.1931	0.0244	0.1756	0.0728	0.199356	0.087592	0.157092	0.0606
town_play	-0.0837	0.0358	0.0567	0.1062	0.263595	0.149829	0.349679	0.0982
lnminlot	-0.0161	0.0015	-0.0205	0.0044	-0.00104	0.003762	-0.00971	0.00191
lnareaft2co~t	0.0982	0.0049	0.1011	0.0269			0.108958	0.00736
lnrealimpradj	0.0857	0.0014	0.0837	0.0085			0.090166	0.00163
condo	0.3312	0.0243	0.3740	0.1622			0.438024	0.0287
lnshore_dist	0.2136	0.1721	-0.3032	2.1322			0.550529	0.256
bay_dummy	0.0787	0.0216	-0.0041	0.0940			-0.04895	0.0341
lndist_gb	5.3667	3.0785	-7.9731	30.3967			4.303432	4.635
lnslope	0.0119	0.0189	-0.0050	0.0519			0.009727	0.0269
lnflooding	-0.0215	0.0206	-0.0226	0.0317			-0.04905	0.0285
lnbsmt	-0.1901	0.0294	-0.1881	0.0583			-0.20648	0.0414
year FE	YES		YES				YES	
spatial FE	NO		MUN				PIN	
spatial * time	NO		NO				NO	
AIC	65,351.53		64,883.00					

Table 4: Spatial fixed effects and interaction terms (log-log) and yellow is significant at <=5% and orange is <=10%

	log-log(2)	MUN(2)	MUN(3)	Repeat sales(2)	Repeat sales(3)	HT(2)
	coef	coef	coef	coef	coef	coef
lneasement	0.087	0.154	0.099	0.168	0.127	0.151
lnnat_state	-0.365	-0.490	-0.438	0.450	0.731	0.555
lnco_town	-0.154	-0.064	-0.086	-0.170	-0.230	-0.267
lnridges_uw	-0.317	-0.174	-0.017	-0.161	-0.163	-0.130
lnplay_dist	0.012	-0.022	-0.026	-0.095	-0.168	-0.185
nat_beach	0.182	0.170	0.233	-0.042	-0.009	-0.026
town_beach	0.258	0.243	0.254	0.153	0.201	0.176
town_play	-0.074	0.045	-0.015	0.169	0.298	0.266
lnminlot	-0.013	-0.018	-0.062	-0.001	-0.015	-0.040
lnareaft2co~t	-0.067	0.026	-0.039	1.427	1.526	1.012
lnrealimpradj	0.084	0.083	0.084	0.095	0.098	0.091
condo	0.350	0.397	0.436	0.557	0.550	0.515
lnshore_dist	0.452	-0.158	-0.960			0.010
bay_dummy	0.057	-0.014	0.038			-0.002
lndist_gb	0.269	-6.954	5.885			-10.160
lnslope	0.027	0.011	0.018			0.029
lnflooding	-0.034	-0.034	-0.025			-0.009
lnbsmt	-0.173	-0.172	-0.170			-0.166
lnease*lnlotsize	-0.017	-0.017	-0.011	-0.037	-0.032	-0.029
lnnat_state*lnlotsize	0.000	0.006	0.007	-0.035	-0.055	-0.054
lnco_town*lnlotsize	0.018	0.008	0.009	-0.019	-0.026	-0.023
lnridges_uw*lnlotsize	0.017	0.012	0.011	-0.007	0.003	0.007
lnplay*lotsize	-0.002	-0.002	-0.001	0.002	0.002	-0.001
lnarea_ease	-0.068	-0.010	-0.001	-0.162	-0.133	-0.103
lnarea_nat	-0.315	-0.376	-0.331	0.042	0.060	-0.072
lnarea_co	0.058	0.042	0.023	-0.285	-0.392	-0.399
lnarea_uw	-0.080	-0.018	0.077	-0.161	-0.094	0.031
lnease#c.lnarea_ease	0.007	0.000	-0.002	0.017	0.014	0.010
lnnat_state#c.lnarea_nat	0.031	0.037	0.032	-0.004	-0.006	0.007
lnco_town#c.lnarea_co	-0.005	-0.003	-0.002	0.038	0.046	0.048
lnridges_uw#c.lnarea_uw	0.009	0.003	-0.008	0.018	0.011	-0.001
lnplay#lnarea_play	-0.001	0.002	0.001	0.004	0.005	0.008
year FE	YES	YES	YES	YES	YES	YES
spatial FE	NO	MUN	MUN	PIN	PIN	PIN
spatial * time	NO	NO	MUN* year FE	NO	MUN* year FE	MUN* year FE
AIC	65,103.10	64,610.88	63,394.51	24,038.97	20,750.01	
groups	28,282	18	18	6427	6427	28,282