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Variation in Valuation: Open Space and Geography

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VARIATION IN VALUATION: OPEN SPACE AND GEOGRAPHY

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Abstract
We estimate hedonic valuation models of local open space separately for 215 cities in the Eastern US, and derive city-specific marginal willingness to pay (MWTP). We then examine variation in MWTP and city-level determinants. Valuation is largely local – relatively large changes in income or existing conservation lead to modest changes in MWTP – suggesting validity of benefit transfer across regions. However, geographic features that naturally limit development do correlate with MWTP. As a result, we examine geographic features as instrumental variables, and find that on average steep slope and water/wetlands yield valuation coefficients of opposite sign, consistent with a LATE interpretation.

Keywords: valuation, open space, instrumental variables
JEL codes: Q24, Q51, R31

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1. Introduction

Every day an estimated 6,000 acres of open space are converted for other uses, such as urban and suburban expansion (U.S. Forest Service 2019). The forfeiture of these lands for development may assuage the needs of a growing population, but lead to a loss of benefits to the individual and surrounding neighborhoods. Open space provides benefits from recreational and visual amenities as well as other ecosystem services like improved air and water quality (US Forest Service 2019). As a result, permanently protecting open space is a policy priority for many local, state, and federal governments and NGO's. However, conserving land can be costly and in many cases the benefits of conservation may be unknown and welfare measures imprecise.

There are three objectives to this paper. First, we seek to estimate how the valuation of local open space varies across space using the hedonic housing price model applied to many markets across the entire Eastern United States. While there are many papers in this vein of research (e.g., Geoghegan et al. 1997, Irwin 2002, Song and Knaap 2004, Anderson and West 2006, Cho et al. 2009, Poudyal et al. 2009, Klaiber and Phaneuf 2010, Netusil et al. 2010, Black 2018), these studies only use data from one city or state, which leaves open the question of how valuation varies across space and the validity of benefit transfer from one city/state to another.[1] Second, we aim to understand how geographic features that naturally limit development affect valuation. Saiz (2010) shows that water features and steep slopes limit development, so we assess whether these features act as complements or substitutes to the valuation of conserved land. Third, we investigate how local geography can be used to instrument for preserved land. Irwin and Bockstael (2001), Irwin (2002), and Geoghegan et al. (2003) use steep slope to instrument for open space in Maryland. Using our more comprehensive database, we can assess the performance of this instrument, as well as one based on water and wetlands, across many cities and place prior results in context.

To achieve these objectives, we build a comprehensive dataset of housing and neighborhood characteristics and land use across 215 Metropolitan Statistical Areas (MSAs) in the eastern half of the United States. We use the American Community Survey at the block group level, and measure conserved land, slope, and water and wetland features at the same level using GIS and the National Land Cover Database.

[1] Lang (2018) uses data from across the United States, but assumes homogenous treatment effects.

For each MSA in our dataset, we estimate a separate hedonic valuation model regressing median home value on protected open space at the census block group level. Our specification controls for unprotected open space and numerous housing and demographic variables. We also include county fixed effects and quadratic functions of latitude and longitude to guard against spatial unobservables that could be correlated with housing prices and open space. The local valuation results are consistent with previous literature and indicate positive housing premiums for proximity to open space. For example, a 1% increase in *Proportion Protected Open Space* is associated with a 0.14% increase in housing prices in the New York City MSA. We then calculate marginal willingness to pay (MWTP) for each MSA separately by multiplying the estimated premium by the average house price. The mean MWTP across all MSAs is $499, and the standard deviation is $284.

We seek to explain the variation in valuation by estimating a second model that regresses MWTP for protected open space on various geographic variables measured at the MSA level.[2] We hypothesize that the amount of naturally occurring open space from undevelopable areas will decrease MWTP because it is a substitute. In contrast, our results suggest that a one standard deviation increase in the amount of *Undevelopable Area* increases MWTP by about $49, making it a complement. We further break undevelopable area into its two components, steeply sloped land and water/wetlands, and find opposite results. While water/wetland areas act as a complement to preservation, steeply sloped areas act as a substitute and reduce MWTP. Our model additionally includes the amount of protected open space in the MSA, which, consistent with expectations, is negatively relative to MWTP. However, while geography and the quantity of conservation do affect MWTP, the changes are relatively small. Marginal changes in geography have essentially zero impact on MWTP. We interpret this to mean that the majority of valuation is local and not greatly affected by conservation activities and geography in the larger MSA environment, which implies that benefit transfer is likely valid across many MSAs in this context. Our model also includes average temperature and log per capita income. Income is positively correlated with MWTP, and temperature has no discernable effect. The latter is consistent with valuation being local, and not based on the particular ecology of conserved land.

[2] This multi-market approach is similar to those of Boyle et al. (1999), Zabel and Kiel (2000) and Wang et al. (2012), though we use far more markets.

Previous studies (Irwin 2002, Saiz 2010) and intuition suggest that geographic features that limit the developability of land may provide observable open space free from endogeneity problems. Slope has been commonly used as an instrumental variable in the open space valuation literature because steeply sloped land is difficult to develop and hence is arguably exogenous open space (Irwin and Bockstael 2001, Irwin 2002, Geoghegan et al. 2003). Given our findings of a negative relationship between sloped land in an MSA and MWTP, and the complementary relationship between water/wetlands and preservation, we revisit the use of these geographic variables as instruments. The large geographic scope of our data allows us to examine how slope and water/wetlands perform as an instrument across many housing markets. In the first stage, we find that across most MSAs, both slope and water/wetlands are typically a strong positive predictor of protected open space indicated by positive and statistically significant coefficients and large F-statistics. However, there is considerable variation in the second stage valuation results. Despite qualitatively replicating the IV valuation results for Maryland, the average second stage coefficient when using slope as the instrument is -0.84, indicating a counterintuitive negative valuation of protected open space. In contrast, the average second stage coefficient when using water/wetland as the instrument is 0.20, implying positive valuation of protected open space. We conclude that it is necessary to interpret the IV results as a local average treatment effect (LATE); when there is heterogeneity in treatment effects, an IV identification strategy will estimate the treatment effect associated with the specific variation caused by the instrument (Angrist and Pischke 2008). In this context, the IV valuation coefficient does not reflect valuation for all protected open space, but just valuation for protected open space that is associated with steeply sloped land or water/wetland features. Ironically, IV estimates are likely less useful for benefit transfer.

The paper proceeds as follows. Section 2 details the data used. Section 3 presents the methods and results for local valuation and comparing MWTP across MSAs. Section 4 presents the IV analysis. Section 5 concludes.

2. Data

Our area of study includes data from the 26 states east of the Mississippi River. We exclude the western United States due to the large variation in precipitation, land cover, and the prevalence of national parks. Our study area contains over 129,000 census block groups, 215

Metropolitan Statistical Areas (MSA), 240 million acres of land, and 148 million people. We then eliminate any block groups that fall outside of an MSA boundary or have missing data.[3] Our final dataset includes 103,052 block groups within 215 MSAs.

We obtain census block group level housing and socioeconomic variables from the 2009-2013 American Community Survey (ACS) from the US Census Bureau.[4] These data include several structural housing characteristics such as number of bedrooms, construction year, and median home value. Additionally, the socioeconomic data available include age, employment, proportion of renters, housing vacancy, income, race, and education.

There are multiple sources of housing data available for hedonic modeling, and there are benefits and costs of each. Prior research on valuation of open space has typically used individual housing transactions (Irwin 2002, Anderson and West 2006). While these data allow for fine detail about proximate land use characteristics, they are typically proprietary and difficult or expensive to collect, which limits the geographic scope of analysis. In contrast, housing data from the US Census (or another aggregate source like Zillow) allows for analysis of the entire United States, and this feature has been advantageously used by research evaluating national-scale environmental programs (Greenstone and Gallagher 2008, Bento et al. 2015) or disamenities or events that infrequently occur in a given area (Davis 2011, Lang 2018). Because the focus and contribution of this paper come from comparing valuation across geographies, we choose to use Census data. However, this choice restricts the details about proximate land use we can include in our local valuation model, and we acknowledge this as a limitation.

Land use data come from the United States Geological Survey (USGS) 2011 National Land Cover Database (NLCD). This dataset includes land cover types, locations and topographic features. For the purposes of our study, we define open space as the sum of water, forests, barren land, developed open space (parks, golf courses etc.), agricultural lands, and wetlands. We then distinguish our definition of open space in two separate ways. Using USGS Protected Area Database (PAD) shapefiles in GIS, we are able to identify which areas are conserved as well as who owns them. For our study we define *Proportion Protected Open Space* as any open space that falls within a PAD conserved area. Our definition for *Proportion Unprotected Open Space* is

[3] The Cape Girardeau-Jackson MO-IL MSA was dropped because it only holds 9 block groups, which does not provide enough variation to estimate our model without substantial bias.
[4] The ACS is published annually in 5-year rolling averages. We chose to use the 2009-2013 version because it is centered on the year 2011, which is the year of our land cover data.

all remaining open space or developed open space. We use GIS to calculate *Proportion Protected Open Space* and *Proportion Unprotected Open Space* within each census block group for our local valuation analysis.

We also use GIS to combine wetland features and water feature layers from the NLCD. We then sum their levels within each census block group to define our *Water/Wetlands* variable. Additionally, we incorporate the USGS's 3D Elevation Program dataset, which maps elevation levels across the United States, to define our variable *Area with Slope Over 15%*.

There are additional variables that are unavailable directly from the ACS or USGS, such as lot size, longitude and latitude, and distance to nearest CBD. We calculate a measure of average lot size by using data on total developed land and dividing by number of housing units in a census block group. Using GIS, we obtain longitude and latitude coordinates for each census block group centroid and calculate the Euclidean distance between each census block group and its Central Business District (CBD).

For estimating models that compare MWTP across MSAs, all data must be aggregated to the MSA level. To calculate *Protected Open Space,* we sum the total acres of protected open space for all block groups within an MSA and divide that by the total acreage in that MSA. *Undevelopable Area* is similarly calculated by summing the total acres in a MSA with slope over 15% and water and wetlands land cover types over the total acreage for that MSA. Mean annual temperature is collected from Weather Underground. Lastly, we also gather county-level aggregate 2012 Presidential Voting data from Election Atlas.

3. Variation in Valuation

3.1 Methods

The traditional theory behind the hedonic pricing model (Rosen 1974) relates the value of a good to its bundled attributes. Applied within the housing market, the hedonic model uses a property's value to reveal preferences for different structural and locational characteristics, including environmental amenities. The market equilibrium is portrayed by a hedonic price function that is the tangency of bids from buyers and offers from sellers. Differentiating the price function with respect to an observed trait reveals the individual's marginal willingness to pay for that attribute. The hedonic price function can be represented as

(1) $P_i = f(H_i, N_i, E_i)$

where P_i is the sale price of the *i*th home, H_i is a vector of a property's structural characteristics, N_i is a vector of neighborhood and locational characteristics, and E_i is a vector of environmental amenities.

Using census and land use data detailed in Section 2, the specific local valuation model we estimate is:

$$(2)\ \ln(P_{icm}) = \beta_{1m} Proportion\ Protected\ Open\ Space_{icm} + \beta_{2m} Propertion\ Unprotected\ Open\ Space_{icm} + \boldsymbol{X_{icm}\delta_m} + \pi_c + \varepsilon_{icm}$$

where P_{icm} is the log median house price for census block group *i* in county *c* in MSA *m*, *Proportion Protected Open Space* is the proportion of acres within census block group *i* that is protected or conserved open space. We include *Proportion Undevelopable Open Space* as the proportion of acres within block group *i* that is unprotected, or developable, open space. ***X*** is a vector of housing and neighborhood characteristics. We also include county fixed effects (π_c) and spatial coordinate controls specifically longitude, longitude squared, latitude, and latitude squared, which mitigate bias stemming from uneven and non-random distribution of open space.

β_{1m} is the coefficient of interest and is interpreted as a one percentage point increase in protected open space is associated with a β_{1m}% change in housing prices. We expect the coefficient on *Proportion Protected Open Space* to be positive, due to the stream of benefits received from sustained accessibility and use of land, $\beta_{1m} > 0$. For the coefficient on *Proportion Undevelopable Open Space* we also expect a positive effect but of smaller magnitude than β_{1m}. Due to the possibility of future development, it may not remain open space and the stream of benefits received by properties will likely be discounted, $\beta_{1m} > \beta_{2m} > 0$.

Importantly, we estimate Equation (2) separately for each MSA in our dataset. Thus, we are estimating MWTP for local open space across many different housing markets, each with its own population and geographical characteristics.

Using these estimates, we then develop a secondary model that examines geographic factors that affect MWTP estimates for protected open space. The dependent variable in our second model, $MWTP\ for\ Protected\ Open\ Space_m$, is the estimated MWTP for open space for MSA *m* and is calculated by multiplying $\hat{\beta}_{1m}$ by the average median house price from that MSA. We estimate the following model:

(3) $MWTP\ for\ Protected\ Open\ Space_m = \gamma_1 Protected\ Open\ Space_m + \gamma_2 Undevelopable\ Area_m + \gamma_3 Mean\ Temperature_m + \gamma_4 Log\ Per\ Capita\ Income_m + \varepsilon_m$

where *Protected Open Space* is the percentage of total area that is protected open space within MSA *m*. We predict that this coefficient will be negative, $\gamma_1 < 0$, suggesting that as the amount of protected open space increases the less people are willing to pay for more of it. *Undevelopable Area* is the percent of total area that is undevelopable within MSA *m*. We follow the logic of Saiz (2010), who establishes a measure of "undevelopable" area where development of residential property is improbable. We define undevelopable as any area of wetlands, rivers, lakes, oceans or other water features or land area with slope over 15% contained within the boundaries of the MSA as set forth by the census GIS shapefile. We hypothesize that $\gamma_2 < 0$ because naturally occurring open space will act as a substitute to preserved land. *Mean Temperature* is average annual temperature. We hypothesize that $\gamma_3 = 0$ because the value of proximate preserved land is unlikely to reflect specific ecology, but rather views, access, and character. However, if $\gamma_3 \neq 0$, this may have implications for an additional impact of climate change. *Log Per Capita Income* is the logged per capita income averaged across all census block groups within MSA *m*. We expect the coefficient on income to be positive, $\gamma_4 > 0$, as areas with more income are able and willing to spend more on environmental amenities like open space.

We also estimate a variant of Equation (3) that splits the measure of undevelopable area into a water and wetlands component and a slope component in order to assess if these geographic factors correlate with MWTP differently.

(4) $MWTP\ for\ Protected\ Open\ Space_m = \gamma_1 Protected\ Open\ Space_m + \gamma_2 Area\ with\ Slope\ Over\ 15\%_m + \gamma_3 Water/Wetlands_m + \gamma_4 Mean\ Temperature_m + \gamma_5 Log\ Per\ Capita\ Income_m + \varepsilon_m$

Area with Slope Over 15% is the proportion of land with a slope gradient over 15% within MSA *m,* and *Water/Wetlands* is the proportion of water bodies and wetlands within MSA *m*. We expect both variables to be negatively related to MWTP as both act as natural substitutes to preserved land.

Equations (3) and (4) are estimated using weighted least squares, with MSA observations weighted by their total population.

3.2 Assumptions

Several econometric identification problems arise in the hedonic literature relating to the endogeneity of open space variables. The quantities of open space within a census block group or MSA is not random and is heavily influenced by factors such as developability and the spatial characteristics related to home values in different areas. Many of these factors are unobservable and may be correlated with both open space and housing prices. For these reasons bivariate regression almost certainly leads to biased estimates of MWTP in our local valuation model.

However, several clever strategies have been used to mitigate this endogeneity issue. Anderson and West (2006) mitigate bias from omitted spatial variables by including block group level fixed effects in their model, and Lang (2018) uses a regression discontinuity in conservation referendum voting outcomes. Other studies use an instrumental variable approach. Research that uses geographic features like slope and soil quality (e.g., Irwin and Bockstael 2001, Irwin 2002, Geoghegan et al. 2003) are most credible.[5] In Section 4, we explore replicating the use of slope as an IV, but find it is not a viable strategy because steeply sloped protected open space is not universally valued across MSAs.

The necessary assumption we make is that protected open space is exogenous after conditioning on unprotected open space, housing attributes, neighborhood socioeconomic characteristics, and spatial controls. In terms of identification, our study is most similar to that of Anderson and West (2006). We argue that this rich set of parametric and non-parametric controls mitigates bias from unobservables, and we proceed cautiously from there.

Further, we argue that even if some bias remains in our valuation estimates, our MWTP determinants model results will still hold. Bias in the first model will impact the absolute magnitude of MWTP estimates, but if the bias is similar across MSAs, then the relative ordering of MWTP will be the same and our analysis of MWTP shifters will be valid.

3.3 Local Valuation Results

We report a selected portion of our local valuation model results since it is not feasible to present results for all 215 MSAs. Table 1 presents results from estimating Eq. (2) for three sample MSAs, which were chosen because they are well-known and vary regionally and

[5] Some studies use instruments that do not pass the exclusion restriction. For example, Poudyal et al. (2009) use neighborhood income as an instrument, even though this surely influences housing prices.

socioeconomically. Each column displays the results from a different MSA. Our key independent variable, *Proportion Protected Open Space*, is positive and statistically significant across all three columns, which is consistent with other findings in the literature (Irwin 2002, Anderson and West 2006). For example, the coefficient of 0.14 in Column 1 suggests that a 1 percentage point increase in *Proportion Protected Open Space* in a block group is associated with a 0.14% increase in median home value in the New York City MSA. Similarly, *Proportion Unprotected Open Space* coefficients are positive and statistically significant across all three columns, and are smaller in two of the three cases, as expected.

Housing and demographic covariates are mostly consistent with expectations. *Distance to CBD* and its polynomial are statistically significant and indicate a U-shape relationship. Other variables like *Proportion College Educated*, *Proportion High School Dropout*, and *Log Per Capita Income* are all statistically significant and fall in line with previous literature on neighborhood determinants of property value (Irwin 2002, Poudyal et al. 2009).

Only a few MSAs' coefficients are observed in Table 1, but to visualize the varying estimates and their geographic locations we map them using GIS. Figure 1 plots estimated MWTP for all 215 MSAs in our study area. The population weighted mean MWTP for protected open space is $499, but ranges to over $2500. More than 85% of recovered estimates across all MSAs were positive. A majority of the positive MWTP estimates were greater than $250. We report the 25th and 75th percentiles as $171, and $581, respectively. We note an interesting pattern, the coastal MSAs seem to have higher MWTP than some of the more inland MSAs. Research has suggested that increasingly dense urban areas are more likely to support preservation efforts than less populated spaces (Altonji et al. 2016). This might help explain why larger coastal cities, that have overtaken much of the remaining open space with urban development, may value conserved lands more than other areas with abundant land cover.

3.4 Determinants of MWTP Model Results

Table 2 presents our results from estimating Equation (3) in Column 1 and Equation (4) in Column 2. In order to compare coefficients across variables with different units, we transform all independent variables into z-scores to enable comparisons across variables with different units. For reference, the table displays the standard deviation of each variable.

The coefficient on *Protected Open Space*, is negative and statistically significant in both specifications. As the amount of protected open space increases MWTP decreases. The Column 2 results indicate that a one standard deviation increase in protected open space decreases MWTP by $40.72. Given the immense effort and cost that would be needed to increase protected areas one standard deviation (or 25%), the decline in MWTP is remarkably small. If interpreted as a demand curve, the slope is quite elastic.

In Column 1, the sign on the *Undevelopable Area* coefficient contradicts our hypothesis, as the results suggest that exogenous open space acts as complement to protected open space. A one standard deviation increase in undevelopable land is associated with a $48.62 increase in MWTP. In Column 2, we split *Undevelopable Area* into its two geographic components; *Water/Wetlands*, and *Area with Slope Over 15%*, which sheds some light on this complement relationship. We find that the coefficient on *Area with Slope Over 15%* is negative and statistically significant indicating a substitute relationship, which is closer to our original expectation. On average a one standard deviation increase in *Area with Slope Over 15%* decreases MWTP by $42.08. In contrast, the coefficient on *Water/Wetlands* is positive and statistically significant, indicating a complementary relationship. For a one standard deviation increase in *Water/Wetlands* MWTP increases by $53.95. From a statistical perspective, it is clear that the positive coefficient on *Undevelopable Area* in Column 1 is driven by the effect of *Water/Wetlands*. The results seem to suggest that water features enhance the value of protected land, perhaps through new recreation opportunities or pleasing views, whereas steeply sloped land detracts from the value of protected land, acting as a substitute or providing recreation or views that fewer people enjoy. Consistent with the coefficient on *Protected Open Space*, these coefficients are small relative to mean MWTP. Hence while geography can affect MWTP, the changes are small, which we interpret to mean that the majority of valuation is local, and not greatly affected by conservation activities and geography in the larger MSA environment.

There is little research to compare these results to, the one exception being Lang (2018), who examines the impact of referendum-authorized land conservation spending on home prices across the U.S. He finds that capitalization is lower in areas with higher levels of undevelopable area. The author reports that steeply sloped lands comprise 72% of the undevelopable area in his data set, so we can infer that most of that smaller price effect is driven by slope. He proposes that there may be diminishing marginal benefits to conserving areas with more undevelopable open space, which lends itself to our story of steeply sloped lands acting as a substitute.

Mean Temperature has no statistical effect on MWTP in either specification. This aligns with our hypothesis and bolsters the idea that valuation is primarily local and not based much on surrounding geography.

The coefficient on *Log Per Capita Income* is positive and statistically significant in both columns, indicating that protected open space behaves as a normal good, as income increases people are willing (and able) to spend more on protected open space. The results of Column 2 suggest that a one standard deviation increase in *Log Per Capita Income* increases MWTP for protected open space by $109.60. The magnitude of this coefficient is the largest of any in the model, suggesting that an area's wealth has a larger impact than geography on valuation.[6]

4. Geographic Instrumental Variables

4.1 Methods

As previously discussed, geographic features that limit development can be utilized as instruments to identify exogenous open space. Irwin (2002) and Saiz (2010) argue that steeply sloped land and water features exogenously increase the cost of development or prohibit it entirely and hence provides exogenous variation in open space. Irwin and Bockstael (2001), Irwin (2002), and Geoghegan et al. (2003) exploit this idea by including slope as one of several instrumental variables in their analyses of open space valuation in suburban and exurban Maryland and find positive, statistically significant housing premiums in proximity to open space.

The results found in Section 3.4 suggest that steeply sloped lands are negatively correlated with MWTP and water/wetlands are positively correlated with MWTP. Together, these findings lead us to question the applicability of geographic instruments across different

[6] While geography is our main focus, we also estimate extensions of Equation (4) that include various socioeconomic variables that have been previously shown to relate to preferences for open space (political partisanship, education, and homeownership) in Online Appendix Table A1. Among these variables, only % homeowner is correlated with MWTP. This makes sense because home buyers are making a long-term investment in an asset and location and are likely to be more cognizant of local surroundings than renters. This result is consistent with Bento et al. (2015) that find housing values are more responsive of amenity changes than rental rates. Despite typically strong results between partisanship and willingness to vote for land conservation (Altonji et al. 2016, Prendergast et al. 2019), no such relationship exists between % Democrat and MWTP. Perhaps the partisan split on voting is based on ideological stances of government spending and not on valuation.

markets. Given the large geographic scope of data used in this paper, we are in a unique position to examine the performance of these two instruments and any disparities in estimated valuation across geographies.

We modify our approach to local valuation of protected open space by building on Irwin's IV strategy to identify exogenous open space across all 215 MSAs.[7] Given the opposite relationships found in Section 3.4, we utilize two separate geographic instruments in our analysis, slope and water/wetlands. We define our first and second stage IV models as:

(5) $$Proportion\ Protected\ Open\ Space_{icm} = \theta_{1m} Geographic\ IV_{icm} + \boldsymbol{X_{icm}\theta_{2m}} + \pi_c + v_{icm}$$

(6) $$\ln(P_{icm}) = \beta_m \widehat{Proportion\ Protected\ Open\ Space_{icm}} + \boldsymbol{X_{icm}\delta_m} + \pi_c + \varepsilon_{icm}$$

Where *Geographic IV* will be defined as either *Proportion of Area Water/Wetlands* or *Proportion of Area with Slope Over 15%*, and these variables are now defined at the block group level. All other variables are as defined above in Equation 2. Again, we estimate these equations for all MSAs separately. We additionally estimate the model for the state of Maryland, while using slope as our geographic instrumental variable, to serve as a better comparison to prior research.

4.2 Results

Tables 3 and 4 report the first and second stage estimates from our IV models for slope and water/wetlands, respectively. Table 3 includes three sample MSAs (same as Table 1) and the entire state of Maryland. Table 4 reports the same three sample MSAs and includes Tampa, an arbitrarily chosen MSA with lots of water features. The first stage IV coefficients in both tables are all positive and statistically significant, which shows that our instrumental variables are highly correlated with land conservation.

The second stage results in Table 3 Column 4 are consistent with the findings in Irwin and Bockstael (2001), Irwin (2002), and Geoghegan et al. (2003) for the state of Maryland, finding positive and statistically significant valuation for protected open space. In Maryland, a 1% increase in protected open space is associated with a 0.31% increase in median home value. However, as we compare results across the sample MSAs we find that this is not always the case.

[7] Irwin (2002) used a set of instrumental variables in the model including soil type and other agricultural variables which we do not account for.

For New York City, a 1% increase in *Proportion Protected Open Space* is associated with a -0.16% decrease in median home value. Results for Chicago are statistically insignificant but negative, and the results for Atlanta match more closely to Maryland's.

In Table 4, the second stage results across all columns suggest a positive or statistically insignificant valuation for protected open space when using water/wetlands as an instrument. In Column 4 we see that for Tampa, a 1% increase in *Proportion Protected Open Space*, on average, leads to a 1.08% increase in median home value. The New York City MSA is likewise positive and statistically significant while Chicago and Atlanta MSAs are not statistically different than zero.

To further understand the heterogeneous results of our IV analysis, Figure 3 presents density plots of our first and second stage IV coefficients for both instruments. The weighted mean for the second stage slope IV coefficients is -0.84, which suggests that the use of sloped lands as an instrument for protected open space on average estimates a negative effect on median home values for most MSAs in our study area. The weighted mean for the second stage water/wetlands IV coefficients is 0.20, conversely indicating positive valuations on average for median home values across MSAs. These overall results suggest that steeply sloped conserved land is less valued that water/wetland conserved land, and is even seen as a disamenity in some places. These results are consistent with our findings presented in Table 2.

It is necessary to interpret these results in the framework of local average treatment effects. When the instrument is slope, the analysis isolates variation in preserved land due to steep slopes, and hence the second stage valuation estimate is a valuation of steeply sloped preserved land, not all preserved land. And similarly for the water/wetlands instrument, the second stage valuation estimate is a valuation of protected land with water/wetland features. We find tremendous differences across space and across instruments in the valuation coefficients, meaning that all protected land is not created equal and the instruments are identifying protected lands that are valued differently. To take the case of Maryland, the results are specific to that state and may be driven by the geography of that state. Maryland is relatively flat, with only 5% of the total area designated steeply sloped. The scarcity of steeply sloped land may drive the positive valuation. Other areas with more abundant steeply sloped areas or just idiosyncrasies of where steeply sloped land is distributed within a MSA may have very different valuation of proximity to those lands. For these reasons we stress caution when employing geographic instrumental variables. They are not a panacea for endogeneity concerns because the LATE estimated depends on local factors.

5. Conclusion

This paper seeks to examine the heterogeneity in protected open space valuation across the Eastern United States and whether natural geography can explain some of that variation. We ground our analysis in the hedonic price method, and using census block group data we estimate housing premiums for proximity to conserved open space. Importantly, we estimate hedonic valuation models for each of 215 MSAs separately, which yields 215 estimates of MWTP. We then seek to explain variation in MWTP across MSAs, and regress it on existing conservation, exogenous open space via steeply sloped lands and water features, mean temperature, and income.

There are two main takeaways from our valuation results. First, geography matters for valuation, but in a nuanced way. Consistent with expectations we find that steeply sloped land is substitute for conserved open space. However, wetlands and water features are a complement that enhance the value of conservation. Second, all determinants of MWTP that we test have a relatively small effect on valuation. Large changes in exogenous open space or existing protected open space only have small changes in the valuation of local open space. For example, suppose the Nashville MSA has a MWTP estimate of $535. If the local government or land trusts chose to conserve an additional 1,000 acres within the MSA, which is a 0.16 percentage point increase, we estimate that MWTP would decline by only $0.27. We interpret this to mean that the majority of valuation is local and not dependent on the larger MSA’s geography. In turn, this implies a high likelihood that benefit transfer will yield reasonable estimates.

Using our comprehensive dataset, we revisit the idea of using geographic development constraints as instruments for protected land. While we are able to produce similar findings as Irwin and Bockstael (2001), Irwin (2002), and Geoghegan et al. (2003) using steeply sloped land as an instrument in Maryland, we find that these positive valuation results are more of the exception than the norm. The average local valuation coefficient across our whole sample is negative. Importantly, these results must be interpreted in LATE framework, which suggests that people in many MSAs may not value proximate, steeply sloped conserved land. In contrast, using water/wetland features as an instrument tends to produce local valuation results that are positive, indicating that people do value proximate, conserved land with water features.

There are a number of possible research directions that stem from these findings. We see likely value in future contingent valuation research that investigates preference for conserved land with attributes related to slope, water features, and surrounding conservation. In addition, hedonic valuation would be advanced by more research with large geographic scope and a focus on heterogeneity instead of a single treatment effect. Lastly, we are struck by disparities between our study that finds the average partisanship of a MSA has no effect on MWTP and many voting studies that find Republicans far less likely to vote for land conservation. Future research should work to better understand how partisanship affects valuation.

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Tables and Figures

Table 1: Local Valuation Results for Sample MSA's

Dependent Variable: Log Median Home Value	(1)	(2)	(3)
Independent Variables	NYC	Chicago	Atlanta
Proportion Protected Open Space	0.14	0.21	0.22
	(0.02)***	(0.03)***	(0.05)***
Proportion Unprotected Open Space	0.15	0.17	0.15
	(0.02)***	(0.03)***	(0.05)***
Distance to Nearest CBD (mi./100)	-2.52	-4.06	-3.12
	(0.28)***	(0.20)***	(0.38)***
Distance to Nearest CBD (mi./100) Squared	0.047	0.06	0.06
	(0.01)***	(0.00)***	(0.01)***
Median Year Built (/100)	-0.10	-0.02	0.02
	(0.03)***	(0.03)	(0.06)
Average Lot Size (acres/100)	0.99	0.78	3.44
	(1.67)	(1.48)	(2.50)
Proportion Unemployed	-0.01	-0.17	-0.07
	(0.01)	(0.06)**	(0.11)
Proportion Vacant	0.72	-0.11	0.18
	(0.04)***	(0.05)*	(0.09)**
Proportion Renters	0.77	0.81	0.57
	(0.03)***	(0.04)***	(0.08)***
Proportion College Educated	0.31	0.49	0.42
	(0.04)***	(0.05)***	(0.09)***
Proportion Highschool Dropout	0.14	-0.25	-0.23
	(0.04)***	(0.05)***	(0.10)**
Log Per Capita Income	0.36	0.49	0.55
	(0.01)***	(0.02)***	(0.04)***
Population Density (pop/acres)	-0.07	-0.07	-0.27
	(0.01)***	(0.03)***	(0.24)
Proportion Black	-0.32	-0.36	-0.40
	(0.02)***	(0.02)***	(0.04)***
Observations	12,416	6,412	2,473
R-squared	0.59	0.76	0.79

Notes: All models additionally include proportion of population over 65, proportion of population under 18, proportion of homes with 0-1 bedrooms, 2 bedrooms, 3 bedrooms, and 4+ bedrooms, latitude, latitude squared, longitude, longitude squared, and county fixed effects. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 2: Determinants of MWTP Results

Dependent Variable: MWTP Estimates from Local Valuation Model		
Independent Variables	(1)	(2)
Protected Open Space (z score)	-50.07	-40.72
(sd = 25%)	(20.01)**	(19.91)**
Undevelopable Area (z score)	48.62	
(sd = 19%)	(22.77)**	
Area with slope over 15% (z score)		-42.08
(sd = 12%)		(14.36)***
Water/Wetlands (z score)		53.95
(sd = 21%)		(22.52)**
Mean Temperature (z score)	0.34	-8.95
(sd =7.9°)	(18.30)	(17.55)
Log Per Capita Income (z score)	120.64	109.60
(sd = $4,700)	(21.89)***	(20.99)***
Constant	498.66	498.66
	(16.90)***	(16.90)***
Observations	215	215
R-squared	0.16	0.21

Notes: All observations are at the MSA level, and include 215 MSA's east of the Mississippi River. Dependent variable is the coefficient estimate on proportion protected open space from the first stage hedonic model estimated for each MSA separately multiplied by the median housing price for that MSA. All independent variables are transformed into z-scores by subtracting the mean weighted by MSA population and then dividing by the standard deviation. Each column shows a different specification. All models weight observations by MSA population. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 3: Slope IV Results for Sample MSA's

	MSA/State			
	NYC	Chicago	Atlanta	Maryland
First Stage				
Proportion of Area with Slope Over 15%	1.05	2.75	1.56	1.57
	(0.05)***	(0.27)***	(0.09)***	(0.16)***
F-stat	411.28	106.30	300.33	94.67
R-squared	0.45	0.24	0.24	0.36
Second Stage				
Proportion Protected Open Space	-0.16	-0.08	0.28	0.31
	(0.08)**	(0.18)	(0.10)***	(0.07)***
R-squared	0.58	0.75	0.78	0.73
Observations	12,416	6,412	2,473	2,322

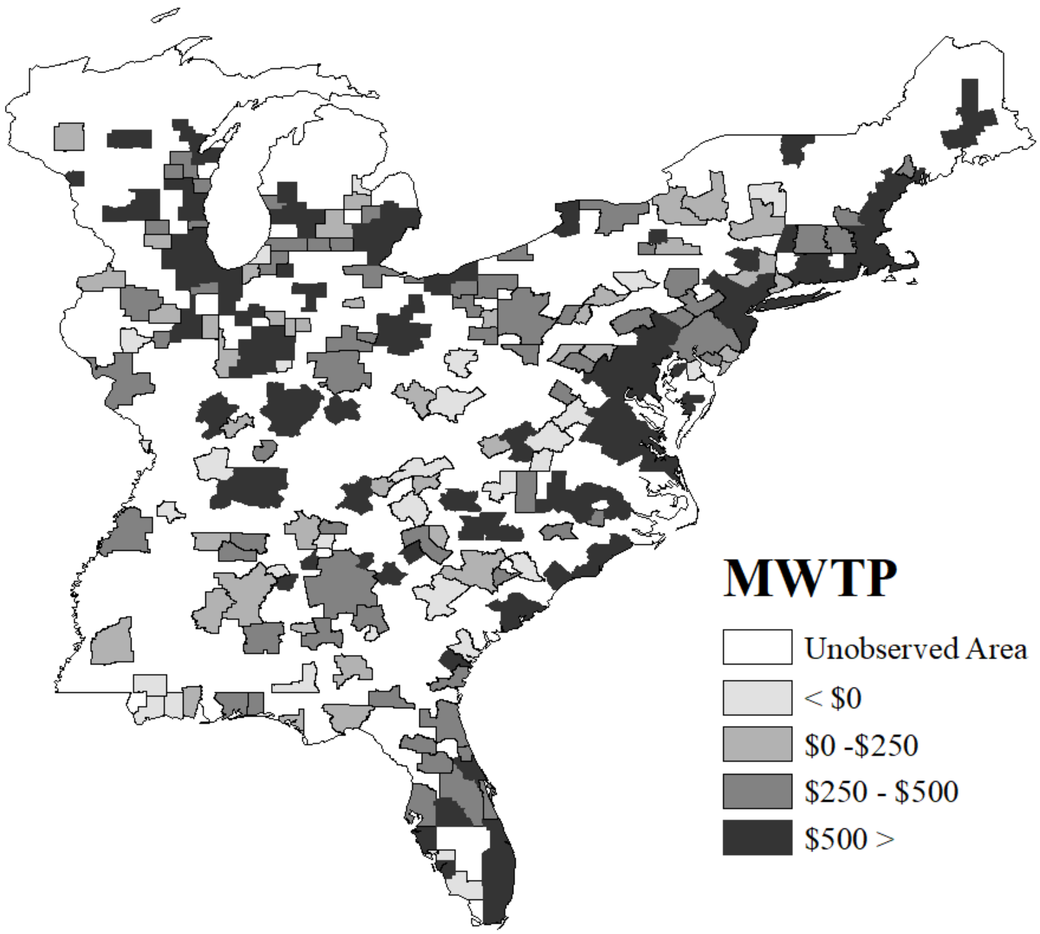
Notes: The dependent variable in the first stage is % Open Space, and the dependent variable in the second stage is log of median home value. The fourth column reports the results for the whole state of Maryland. Each regression uses full set of controls from first stage OLS model. Local Valuation coefficient on Protected Open Space for Maryland is: 0.24 (0.03)***. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 4: Water/Wetlands IV Results for Sample MSA's

	MSA/State			
	NYC	Chicago	Atlanta	Tampa
First Stage				
Proportion of Area Water/Wetlands	0.68 (0.02)***	0.55 (0.02)***	0.16 (0.07)**	0.34 (0.02)***
F-stat	1,925.45	576.96	4.75	228.31
R-squared	0.51	0.29	0.15	0.22
Second Stage				
Proportion Protected Open Space	0.14 (0.04)***	-0.02 (0.08)	0.11 (0.74)	1.08 (0.17)***
R-squared	0.58	0.74	0.79	0.57
Observations	12,416	6,412	2,473	1,920

Notes: The dependent variable in the first stage is % Open Space, and the dependent variable in the second stage is log of median home value. Each regression uses full set of controls from first stage OLS model. Local Valuation coefficient on Proportion Protected Open Space for Tampa is: 0.26 (0.07)***. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Figure 1: Map of Estimated MWTP for Protected Open Space for MSAs



Notes: (< $0): 30 observations, mean -$423, population 6,251,074. ($0 - $250): 44 observations, mean $150, population 12,807,559. ($250 - $500): 67 observation, mean $368, population 43,048,462. ($500>): 74 observations, mean $783, population 85,960,006. Sample Mean: $356. Population Weighted Sample Mean: $499. 25th Percentile: $171. 75th Percentile: $581.

Figure 2: Density of MWTP Estimates

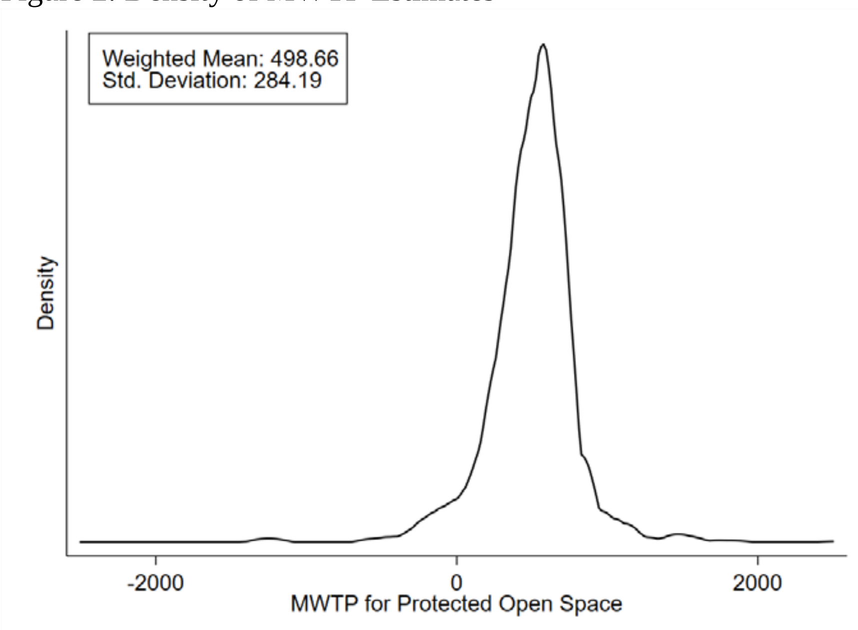
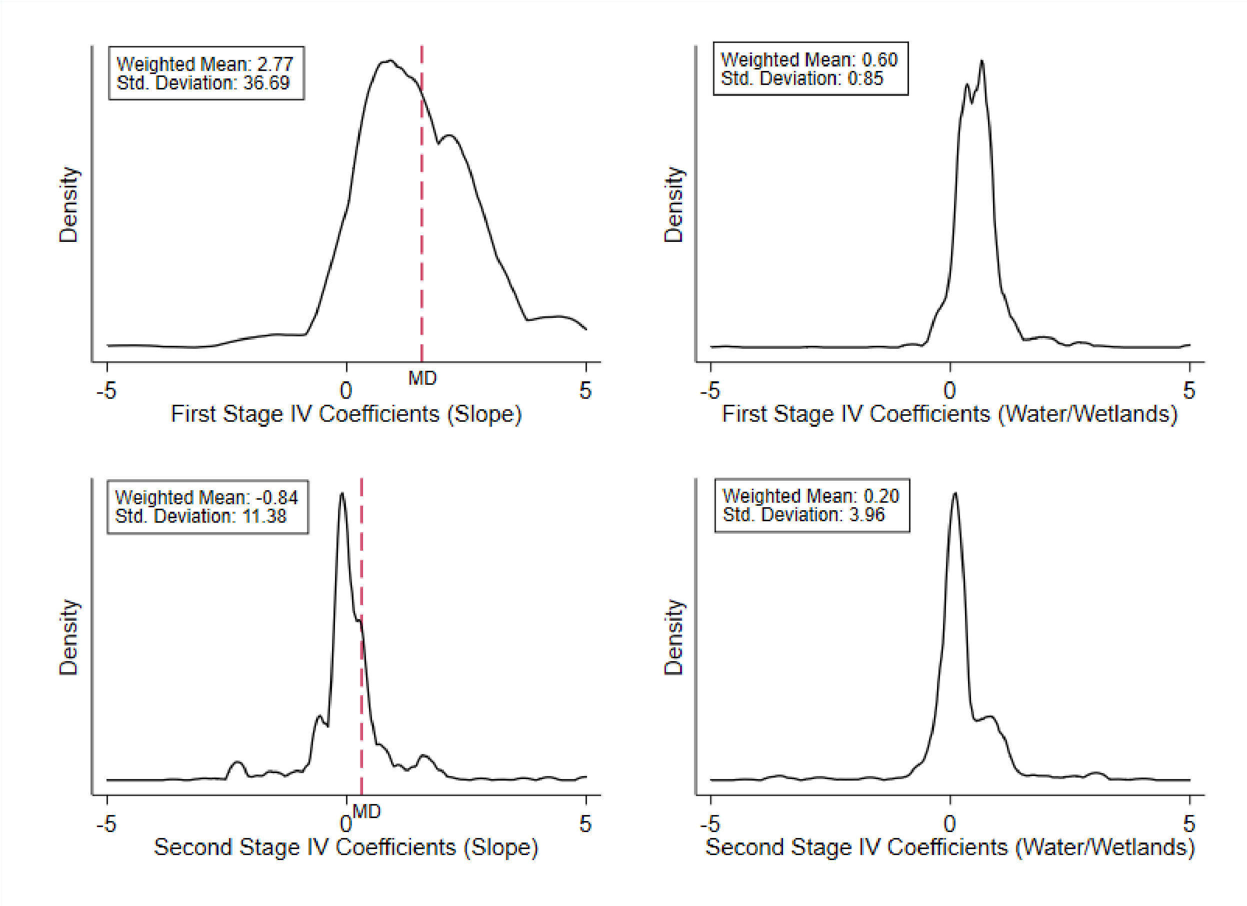


Figure 3: Density Plots of First and Second Stage IV Coefficients



Appendix Table A1: Additional Determinants of MWTP Results

Dependent Variable: MWTP Estimates from Local Valuation Model				
Independent Variables	(1)	(2)	(3)	(4)
Protected Open Space (z score)	-36.43	-43.65	-25.96	-25.55
(sd = 25%)	(18.75)*	(20.91)**	(21.90)	(21.07)
Area with slope over 15% (z score)	-41.83	-33.29	-34.50	-37.40
(sd = 12%)	(13.90)***	(15.62)**	(14.55)**	(14.92)**
Water/Wetlands (z score)	39.86	47.14	60.10	46.16
(sd = 21%)	(23.82)*	(26.96)*	(21.33)***	(25.18)*
Mean Temperature (z score)	-4.54	-0.80	-14.15	-9.66
(sd =7.9°)	(16.70)	(16.77)	(18.63)	(17.36)
Log Per Capita Income (z score)	89.50	98.73	58.98	55.15
(sd = $4,700)	(23.23)***	(32.27)***	(37.01)	(37.24)
% Homeowners (z score)	56.95			53.10
(sd = 5%)	(24.42)**			(21.47)**
% Democrat (z score)		30.51		-3.81
(sd = 10%)		(32.27)		(30.16)
% College Educated (z score)			55.55	40.67
(sd = 4%)			(30.67)*	(27.86)
Observations	215	215	215	215
R-squared	0.24	0.22	0.22	0.25

Notes: All observations are at the MSA level, and include 215 MSA's east of the Mississippi River. Dependent variable is the coefficient estimate on proportion protected open space from the first stage hedonic model estimated for each MSA separately multiplied by the median housing price for that MSA. All independent variables are transformed into z-scores by subtracting from the mean weighted by MSA population and dividing by the standard deviation. Each column shows a different specification. All models weight observations by MSA population. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1