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Disentangling Access and View Amenities in Access-Restricted Coastal Residential Communities

O. Ashton Morgan and Stuart E. Hamilton

In coastal communities with uniform flood risk, amenity value is comprised of two components – view and access. Having controlled for view, it is assumed that any residual amenity value represents the benefit derived from accessing the beach for leisure/recreational purposes. However, as properties closer to the beach typically have improved viewsheds, the two amenities are highly correlated, and disentangling view and access is problematical. A spatial autoregressive hedonic model captures ease of beach access via a network distance parameter that varies independently from property viewshed, collinearity effects are mitigated, and access and view can be disentangled.

Key Words: beach access, property viewshed, spatial hedonic model, willingness to pay

JEL Classifications: Q51, R12, R21, R23

Since Rosen (1974) provided a theoretical platform for estimating the implicit values of housing attributes, hedonic property price models have been used extensively to estimate the value of structural, neighborhood, and locational or amenity attributes in property markets. One important contribution of a number of these studies is the quantification of amenity values in relation to given resources, such as beaches, lakes, oceans, open space, urban parks, and more (Boyle and Kiel, 2001; Lansford and Jones, 1995; Parsons and Noailly, 2004; Parsons and Powell, 2001; Pompe, 2008). Generally, hedonic studies capture amenity value by including a linear distance variable from the property to the resource as an explanatory variable in the hedonic model (see for example, Bin et al., 2008; Bin and Polasky, 2004; Pompe, 2008; Tyrväinen, 1997). However, the benefits of living close to a resource can rarely be defined by a single proximity measure. In coastal markets for example, it is hypothesized that residents derive benefit from both the aesthetic quality that an ocean view provides, and also the ease of access to the beach area for recreation or leisure purposes (Bourassa, Hoesli, and Peng, 2003).[1] While empirically appealing, disentangling viewshed and access amenity values in the hedonic model is econometrically problematical as homes with improved views are typically

O. Ashton Morgan is assistant professor at the Department of Economics, Appalachian State University, Boone, NC. Stuart E. Hamilton is GIS Program Director at The College of William and Mary, Williamsburg, VA.

[1] Typically, proximity should also reflect amenity risk as properties located closer to the water are more likely to have a greater chance of flooding. Bin and Polasky (2004) and Bin et al. (2008) control for risk by including a dummy, equal to one for properties within the Special Flood Hazard Area. We do not control for risk in the model as all properties in the sample are located within the Special Flood Hazard Area, so risk is uniform across the sample.

located closer to the beach area. As such, view and access are highly correlated, raising obvious collinearity concerns. If collinearity is present, then disentangling amenity values may lead to inflated standard errors and imprecise coefficient estimates.

This research seeks to demonstrate that collinearity impacts can be mitigated and reliable estimates of viewshed and access values derived through a more appropriate measure of the access parameter than is typically used in hedonic studies. Previous research that has attempted to separate viewshed and access benefits captures access by including either housing block dummies or a simplistic linear distance parameter from the property to the shoreline (Bin et al., 2008; Parsons and Noailly, 2004; Pompe and Reinhart, 1995). However, in many coastal communities, especially those located along the Eastern Seaboard of the United States, beach-front private property, a vegetated dune structure, and/or local ordinance can restrict beach access to state-designated public access points.[2] As suggested by Bin et al. (2008), the proximity parameter estimate for distance should reflect the ease of access to the shore for leisure and recreation purposes. Therefore, a true measure of access in these communities is not the linear distance to the shoreline, but rather the linear "network" distance from each property to the closest designated beach access point. Economic theory suggests, as individuals seek to maximize utility, they will prefer properties that provide better access to the shoreline, all else being equal. Therefore, in restricted-access communities, having controlled for all other factors, individuals should be willing to pay a premium for properties located closer to designated access points, even if these properties are located farther from the shoreline.

We believe that using a network distance parameter in the hedonic model has two overall benefits. First, it more appropriately measures the ease to which residents access the beach for leisure and recreational purposes in property markets where access is not a function of the linear distance to the shoreline. Second, network access varies independently of view as homes farther from the shoreline with reduced viewsheds can be closer to access points. As such, collinearity effects are likely to be diminished, and our two amenity parameters, access and view, can be separated in the hedonic model.

We follow recent research that utilizes innovations in Geographic Information Systems (GIS) and Light Detection and Radar (lidar) data methods to construct our property viewshed measures (Bin et al., 2008; Paterson and Boyle, 2002). As lidar data accounts for the coastal topography and other property or vegetation obstructions, it has the advantage of providing a more objective and continuous measurement of household viewshed. We also use GIS methods to construct our network access parameter. Due to the high cost associated with developing a continuous measure of viewshed data, we generate a modest sample of coastal property transactions to provide a pilot study that demonstrates the potential benefits of including a network access measure in a hedonic framework when separating amenity values. Results from a spatial autoregressive model indicate that including a more appropriate measure of access into the hedonic model allows viewshed and access to be disentangled. We believe that the robust model results provide a platform for future hedonic analyses where access is an important component of the household purchase decision.

Theoretical Framework

Hedonic property price models are based on the theory of household behavior. This theory suggests that households value a good because they value the characteristics of the good rather than the good itself. In hedonic property price theory, the relationship between property price and the property's various attributes can be expressed as:

$$(1) \qquad \boldsymbol{P} = \boldsymbol{P}(\boldsymbol{S}, D, V)$$

where the sales price of properties, $\boldsymbol{P}$, is a function of a vector of structural attributes, $\boldsymbol{S}$, (such

[2] For example, in Florida, state law precludes beach access via private property but it does provide a policy using the State Comprehensive Plan to ensure that the public has a right to reasonable beach access. As a result, individuals must access the beach via state designated public access points.

as size and age of home, number of bathrooms) D, the distance to closest beach access point, and V, viewscape of the resource from properties.

The housing market is assumed to be in equilibrium, and so, prices are at the market clearing level. Each individual chooses a property and location by maximizing their utility function:

$$U = U(Z, \boldsymbol{S}, D, V) \tag{2}$$

where Z is a composite, representing a bundle of other goods with price equal to one, subject to a utility constraint:

$$Y = \boldsymbol{P} + Z \tag{3}$$

where Y represents income. Assuming that $\boldsymbol{P}(\bullet)$ is continuously differentiable, taking the first derivative of Equation (1) with respect to each continuous housing attribute variable yields the corresponding implicit price of the characteristic. So, estimating the partial derivative of Equation (1) with respect to the viewscape attribute variable yields the first-order necessary condition:

$$\left(\frac{\partial \mathrm{U}}{\partial \mathrm{V}}\right) \Big/ \left(\frac{\partial \mathrm{U}}{\partial \mathrm{Z}}\right) = \frac{\partial \mathbf{P}}{\partial \mathrm{V}} \tag{4}$$

Equation (4) represents the individual's marginal willingness to pay for a change in property viewshed.

Study Area and Data

The study area is Pensacola Beach, located on the western segment of Florida's Panhandle (see Figure 1). Pensacola Beach's location on the Gulf of Mexico and the claim of having the "whitest beaches in the United States" make it a popular tourist destination and desired property location. There are 281 single-family residences

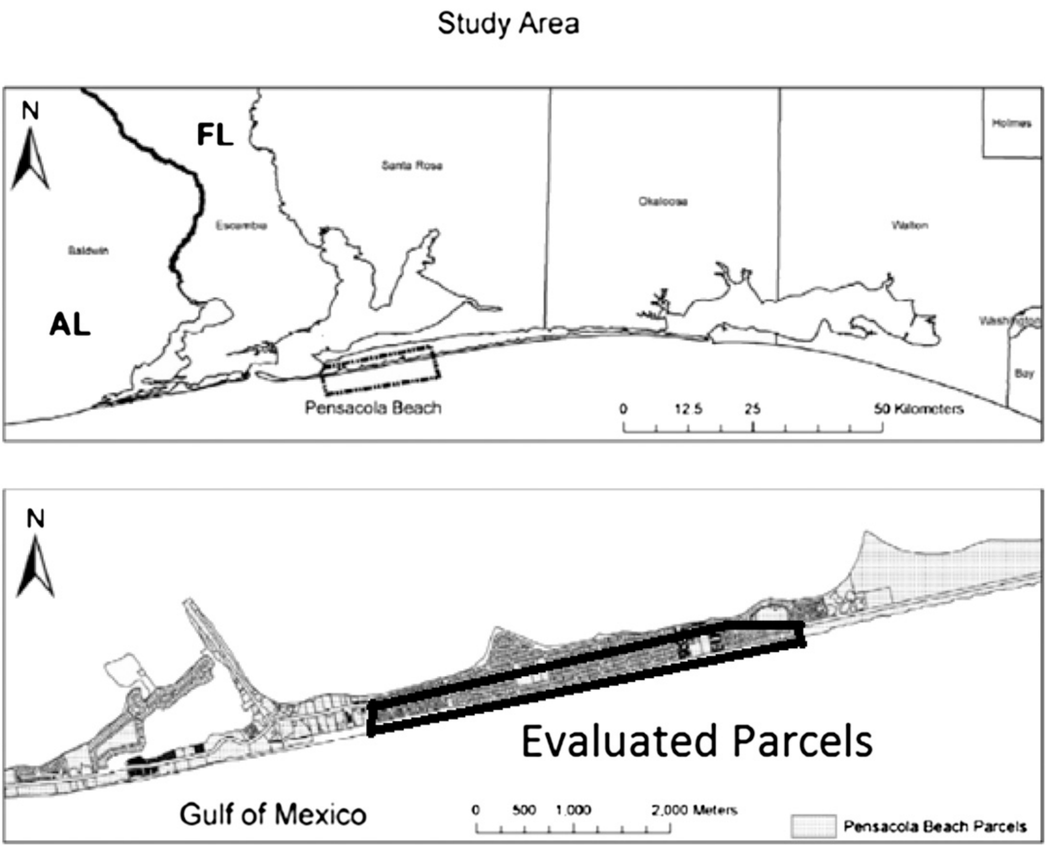

Figure 1. Region of Interest

Table 1. Definitions and Summary Statistics

Variable	Definition	Mean	SD
PRICE	House sales price adjusted to 2007 dollars	559,306.2	429,202.1
YR1998	House sale in 1998 (=1)	0.02	0.14
YR1999	House sale in 1999 (=1)	0.06	0.24
YR2000	House sale in 2000 (=1)	0.13	0.34
YR2001	House sale in 2001 (=1)	0.09	0.29
YR2002	House sale in 2002 (=1)	0.21	0.41
YR2003	House sale in 2003 (=1)	0.09	0.29
YR2004	House sale in 2004 (=1)	0.16	0.37
YR2005	House sale in 2005 (=1)	0.07	0.26
YR2006	House sale in 2006 (=1)	0.07	0.26
YR2007	House sale in 2007 (=1)	0.11	0.32
AGE	Age of house (years)	30.57	11.95
SQFT	Total square footage of house	1,804.25	667.05
BATH	Number of bathrooms	2.28	0.80
GARAGE	Number of vehicles accommodated by garage space	1.08	1.14
NET_ACC	Linear network distance to nearest beach access point	172.64	111.83
SHORE_DIST	Linear distance to shoreline	149.97	78.89
VIEW	Viewscape measured by degree of view across 1000 m distance	42.69	56.69

All distances are in meters (m).

along a two-mile stretch of residential units on the gulf-side portion of Pensacola Beach.

Property price and attribute data come from the Pensacola Association of Realtors database of property transactions.[3] Our dataset contains attribute and sales price information on 101 single-family residences, sold between 1998 and 2007. We include many of the structural housing attributes common to the hedonic literature. Table 1 presents definitions and summary statistics for the variables used in the analysis. The average sales price for homes in the sample is $559,306, adjusted to 2007 prices using the consumer price index for housing. The average home is 31 years of age, with 1,804 square feet of living space, two bathrooms, and a single-car garage. Finally, the average property has a 43-degree viewshed of the shoreline, with a network distance to the nearest access point of 173 meters, and a linear distance to the shoreline of 150 meters.

Measuring Access and Viewshed

Two beach access measures are constructed by calculating (1) the linear network distance between each property in the dataset and the nearest designated beach access point; and (2) the direct linear distance from each property to the shoreline. While gulf-front properties have immediate access to the beach, properties located one, two, or more blocks back must access the beach at a designated point. These beach access points provide the only access to the beach, as gulf-front private property, and/or a vegetated dune structure, and/or local ordinance prohibit merely crossing directly to the beach at other points. As such, a property four blocks back may have a shorter network beach access distance than a property located closer to the shoreline. To illustrate this point, Figure 2 depicts two properties on Pensacola Beach.

This figure represents the gulf side of Pensacola Beach. Via De Luna Drive runs through the middle of the peninsula with all properties to the north (not shown in Figure 2) considered Sound side properties. As all desirable beaches are on the gulf side, all state-designated public access points are on that side of the peninsula.

[3] The authors express their gratitude to the Pensacola Association of Realtors for allowing us to access their database.

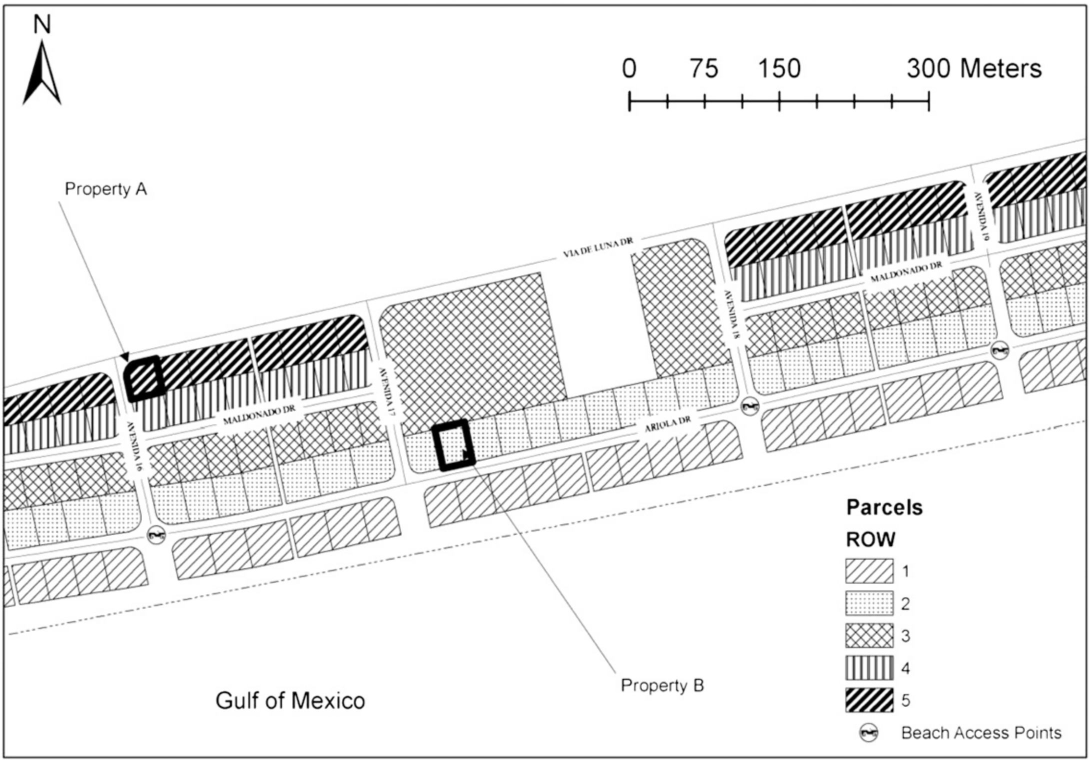

Figure 2. Beach Access

While Property A is located farther from the beach, it is closer to the nearest public access point so it has improved access to the beach relative to Property B. Property A has a network distance from the nearest beach access point of 134 meters, while Property B's network distance is 295 meters. Traditional methods of capturing access would incorrectly imply that Property B has preferable access relative to Property A. Designated beach access points along Pensacola Beach are located using data provided by the Escambia County GIS and Engineering Department.[4]

Access network distance is then calculated from each property to the nearest public access point using GIS. We also use GIS to calculate the conventional linear distance to the shoreline from each property.

We also provide an objective and continuous measure of view for use in the hedonic model. We follow Bin et al. (2008) by constructing the angular viewshed of the shoreline from each property in the sample. Viewshed is measured using lidar data, which provides information on the topographic surface of the coastal area, including all property structures, dunes, and other vegetation, through generating three-dimensional mass-point structures that record the elevation of detected objects by a laser pulse. Pulses are emitted and recorded by lidar instrumentation mounted on a plane that makes multiple flyovers along the beach area. The time it takes for the pulses to reflect back to the lidar sensor determines the surface elevation, having accounted for aircraft pitch and roll (for a thorough description of lidar technology, see Baltsavias, 1999). The elevation data for use in this study were collected in June and July 2006. The measurement of an individual property's viewshed in this study is an angular measurement, noting the

[4] Beach access is only possible at the designated public access points. Any breaks in gulf-front properties that are not designated as public access areas are typically fenced off to prevent individuals from accessing the beach at these locations and damaging dune or vegetated areas.

amount of ocean and beach visible from each individual property. Due to the linear nature of the shoreline in this area, the Maximum View Angle (MVA) of the shoreline is 180 degrees.

Figure 3 provides a schematic to represent the estimated view from two different properties. Property A is located one block back (Row 2) from the shoreline with a vacant lot in front of its property. By extending out a radius viewshed of 1,000 m from the spot elevation determined for this home, an angular measure of viewshed is determined for the property. Property A has 131 degrees of Gulf viewshed. Property B is located two blocks back (Row 3) from the shoreline, and also has vacant property directly in front. It has an angular viewshed of the Gulf of Mexico totaling 39 degrees.

A critical component in capturing viewshed from each property is to determine a common desired observer location in each property from which to make the measurement. The desired observer location used in this study is the window level of the highest livable story of each home, with the observer located at the gulf side of each property. We believe that this technique provides an improvement on other studies that use a standard distance from the elevation of the roof to place the observer (Bin et al., 2008; Paterson and Boyle, 2002). Using a standard distance has the drawback of situating the virtual observer at different points within a property as roof types vary by property. For example, using a standard 3-meter offset for all roof types places the virtual observer at a lower

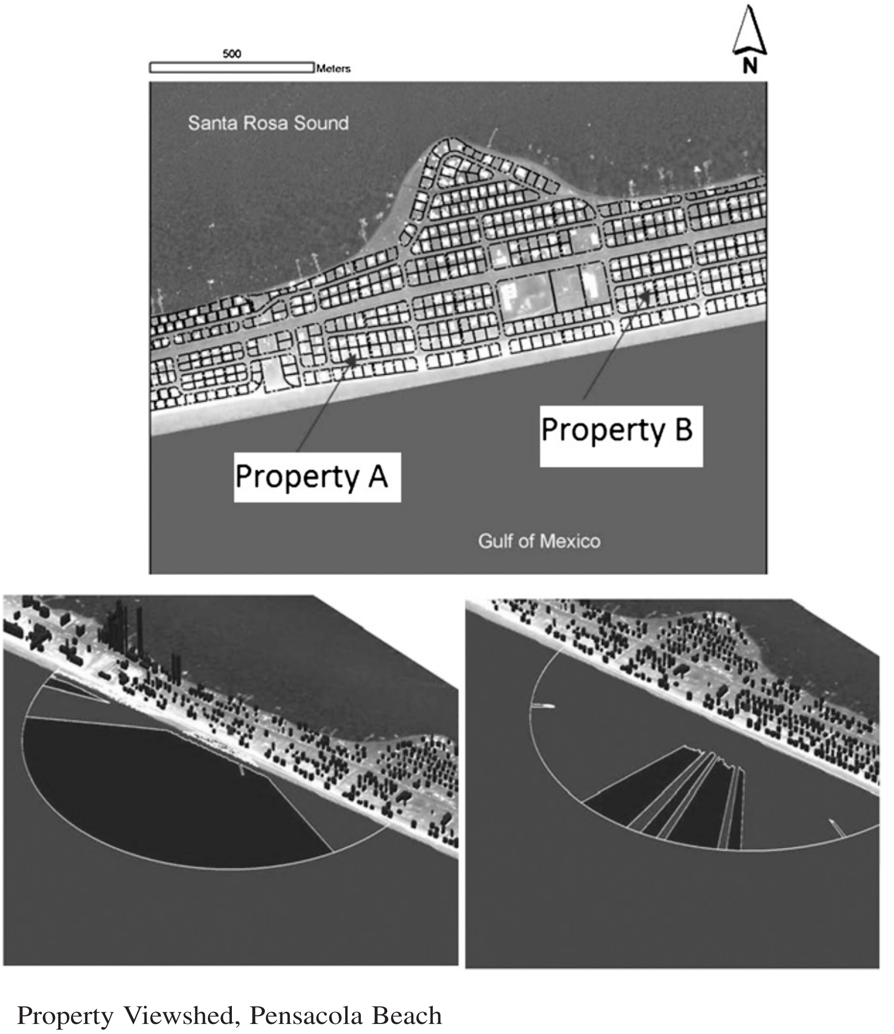

Figure 3. Property Viewshed, Pensacola Beach

point in flat-roofed properties relative to more traditional, angled-roofed homes. This study expands on the process by using lidar and property data to delineate roof type, and hence adjust the offset according to roof structure. Essentially, as properties have different roof structures (flat or angled), we use different offsets, based on roof type, to place the observer at the same desired location for each property. For flat-roofed properties, we assume an observer location of 1.5 meters below the roof level, while for traditional, angled-roofed properties, we assume a 3-meter offset.

We also follow recent research by considering the spatial dependence in the hedonic framework (Bin et al., 2008; Kim, Phipps, and Anselin, 2003; Paterson and Boyle, 2002). This recent research focused its attention on the spatial dependence of error terms in estimated hedonic models. The argument is that interdependence exists among property sales' prices due to the proximity of homes to one another. As such, property sales prices for homes in common neighborhoods are interdependent as they typically share similar housing characteristics and location amenities. Spatial autocorrelation measures the nature, level, and strength of any interdependence, and if present, may be positive or negative. Positive autocorrelation implies that adjacent homes are likely to have similar values (Bin et al., 2008; Paterson and Boyle, 2002), while, negative autocorrelation suggests that one is less likely to observe similar home values for neighboring properties (Irwin and Bockstael, 2002). Failure to account for spatial dependence can violate the assumption of uncorrelated error terms and lead to biased and inefficient coefficient estimates. Spatial dependence can be incorporated into the model in one of two ways. The first possibility is to estimate a spatially lagged dependent variable that assumes that the spatially weighted sum of contiguous property prices is an explanatory variable in the hedonic model. The second method is to estimate a spatial-error model, which assumes that the nature of the spatial dependence is a function of the omitted variables or measurement errors that vary spatially. Based on results from robust Lagrange Multiplier tests, we estimate a spatial-lag hedonic model.[5]

The first step in controlling for potential spatial dependence is to create a spatial weights matrix that reflects the structure of the hypothesized spatial dependence. As suggested by Anselin and Bera (1998), we analyzed the fit of different weights matrices (using different distance measures) in the hedonic model. In estimation, we use a spatial weights matrix consisting of binary elements equal to 1 if two properties are within 100 meters of each other, zero otherwise. The diagonal elements of the weights matrix are set to zero and the row elements are standardized so that they sum to one.

The spatial-lag model takes the form

$$P = \alpha + \beta S + \delta D + \gamma V + \lambda WP + \varepsilon \tag{5}$$

where λ, is a spatial autoregressive coefficient, WP is a vector of spatially lagged dependent variables for W, the weights matrix, and ε is a vector of independent and identically distributed random error terms. The coefficients α, β, δ, γ, and λ are all to be estimated in the model.

Results from the spatial-lag model are then used to estimate the marginal willingness to pay for access and view. As described in Bin et al. (2008), in a spatial regressive model, a marginal change in one of the coastal amenity variables has a direct impact on a property's value but also an indirect impact on neighboring properties. The indirect impact is picked up by λWP in the spatial-regressive model. The sum of the direct and indirect impacts then provides the total impact of a change in access or view on the average price of a property. It should also be noted however, that Kim, Phipps, and Anselin (2003) discuss that the use of the spatial multiplier in marginal benefit estimation is most appropriate for changes that uniformly affect all properties in the sample (such as a change in air quality). In such instances, the housing price in location "*i*" is not only affected by the marginal change in the characteristic of interest in location "*i*," but also affected by marginal changes of the

[5] A robust Lagrange Multiplier test indicated spatial-lag dependence ($\chi^2 = 4.459$; p value $= 0.035$), while a robust Lagrange Multiplier test did not indicate spatial-error dependence ($\chi^2 = 0.408$; p value $= 0.523$).

Table 2. Spatial-Lag Hedonic Property Price Model Results

	Model 1 – Network Distance			Model 2 – Shoreline Distance		
Variable	Coefficient	Standard Error	*p*-value	Coefficient	Standard Error	*p*-value
LAMBDA (λ)	0.0439	0.0114	0.0001	0.0407	0.0117	0.0005
CONSTANT	12.0394	0.3505	0.0000	11.7678	0.3761	0.0000
YR1999	−0.0744	0.2051	0.7165	−0.2157	0.2179	0.3222
YR2000	−0.0709	0.1897	0.7086	−0.1822	0.1989	0.3596
YR2001	−0.1690	0.2016	0.4020	−0.2845	0.2145	0.1847
YR2002	0.0837	0.1872	0.6546	−0.0619	0.1952	0.7510
YR2003	0.1756	0.2027	0.3863	0.0395	0.2109	0.8512
YR2004	0.6283	0.1915	0.0010	0.4924	0.1994	0.0136
YR2005	0.4167	0.2066	0.0437	0.3027	0.2174	0.1639
YR2006	0.7654	0.2052	0.0002	0.6569	0.2157	0.0023
YR2007	0.3558	0.1966	0.0703	0.2454	0.2062	0.2340
AGE	−0.0024	0.0033	0.4651	−0.0010	0.0034	0.7694
SQFT	0.0001	0.0000	0.0625	0.0002	0.0000	0.0201
BATH	0.1117	0.0563	0.0472	0.1229	0.0582	0.0346
GARAGE	0.0970	0.0289	0.0008	0.1059	0.0301	0.0004
VIEW	0.0021	0.0010	0.0253	0.0037	0.0008	0.0000
NET_ACC	−0.0936	0.0304	0.0021			
SHORE_DIS				−0.0337	0.0240	0.1612
R^2	0.83			0.81		
Observations	101			101		

same characteristic in the other locations.[6] While we follow the work by Bin et al. (2008) by including a spatial multiplier in measuring the marginal benefits of changes in property viewshed and access, we acknowledge that changes in the amenity variables may not be uniform across all properties. As such, our use of the spatial multiplier can be considered as providing an upper-bound estimate on the willingness to pay measures. Including the spatial multiplier, the marginal willingness to pay for an improvement in view is given by $\left(\frac{\gamma_{VIEW}}{1-\lambda}\right) \times \boldsymbol{P}$. Following Bin et al. (2008), as the access parameter is log transformed, the marginal willingness to pay for an improvement in access is calculated as $\left(\frac{\delta_{DISTANCE}}{1-\lambda}\right) \times \left(\frac{P}{DISTANCE}\right)$.

Results

As the functional form of the hedonic model is not known *a priori*, we examined different standard functional forms (Freeman, 1993). While results were robust to all alternative functional forms (linear, log-linear, and log-log), log likelihood measures and the significance of the critical variables indicated that the semi-log model was preferred. As such, we estimate and report the results from two semi-log spatial autoregressive hedonic property price models. Parameters are estimated via maximum likelihood within the GeoDa Geospatial Statistical Software v.0.9.5-i (2005) environment. Estimation Model 1 captures access by using the linear network distance from each property to the nearest state-designated public access point while Model 2 includes the standard linear distance to the shoreline as the measure of access. Results from both models are presented in Table 2.

Before discussing the key variables of interest (access and view), some other observations are noteworthy. First, in both models, the spatial autocorrelation coefficient, λ, representing the average influence on observations by neighboring observations, is positive and significant at the 1% level, indicating statistical support for spatial dependence in housing

[6] The authors would like to express their gratitude to one anonymous reviewer for their insights into the appropriate use of a spatial multiplier in marginal benefit estimation.

prices across residential beach properties. All structural variable coefficients have the expected signs in both models, with the structural parameters indicating that the size of the home, the number of bathrooms, and the size of the garage are positively correlated with the property price. Also, older homes are worth less, although this relationship is not statistically significant in either model. Year dummies are also included to capture changes in property price over time with 1998 as the omitted year.

Recall, we posit that network distance varies independently of viewshed so collinearity concerns are mitigated when separating the two amenities in the hedonic model. Before considering the amenity parameters, the correlation matrix provides some support of this notion, showing a high correlation between viewshed and shoreline distance relative to our network access measure and viewshed (see Table 3). While collinearity effects do not reduce the predictive reliability of the model, its presence means that there is a lack of observations for which shoreline distance changes independently of viewshed. Consequently, the standard errors of the amenity variables in the conventional model may be inflated relative to our network access model.

Analyzing the model results with the inclusion of network distance as the access measure (Model 1), the findings show that in access-restricted communities, access is important. The net access variable (NET_ACC) is negative and significant indicating that households are willing to pay more for homes closer to access points, *ceteris paribus*. We find that, on average, households are willing to pay $317 for a 1-meter decrease in distance to the nearest access point. Results from Model 1 also suggest, as expected, that an increased view of the shoreline increases a property's value. We estimate a marginal willingness to pay of $1,228 for a 1-degree increase in property viewshed. This finding is in line with Bin et al. (2008), who estimate a willingness to pay of $995 for a 1-degree increase in viewshed on coastal properties across North Carolina coastal communities.

Table 3. Correlation Matrix

	Shoreline Distance	Network Distance	Viewshed
Shoreline Distance	1.00		
Network Distance	0.668	1.00	
Viewshed	−0.835	−0.592	1.00

Comparing these results with the conventional model (Model 2) highlights the concern associated with disentangling amenity values while using a direct linear distance measure for access. In the conventional model, while the viewshed parameter remains positive and significant, the shoreline distance access measure (SHORE_DIS) is statistically insignificant. This suggests that the presence of collinearity has inflated the standard errors of the distance variable, leading critically to the conclusion that access is not an important amenity characteristic in the home purchase decision. Overall, comparison of the models illustrate that while disentangling the amenity values provides the researcher with important practical information on household behavior, a conventional model that fails to account for access restrictions may generate unreliable amenity parameter estimates.

We believe that many hedonic studies overlook the importance of the access amenity in the home purchase decision. Property markets in communities proximate to beaches, ski resorts, parks, and lakes all generate a desire for access, in which typically, access is not a function of the linear distance to the resource. Not only does the conventional linear distance model fail to adequately capture this access issue, it also makes disentangling access and viewshed problematical in a hedonic modeling framework. Our findings suggest that inclusion of a network distance measure in the hedonic model not only provides a more precise indicator, and therefore, measure of access, but can mitigate collinearity concerns, and yield more reliable amenity value coefficient estimates.

Conclusion

In urban coastal communities, residents derive benefit from both the aesthetic quality that an ocean view provides, and also the ease of access to the beach area for recreation or leisure purposes. Ideally, researchers would like to disentangle and measure the value of both amenities. However, in a conventional hedonic framework where access is measured by the linear distance from each property to the shoreline, this is problematical as view and distance are often highly correlated. Consequently, the standard errors of the amenity variables may be inflated, generating unreliable coefficient estimates.

We argue that, as many residential coastal communities have beach-front private property, a vegetated dune structure, and/or local ordinance that restrict access to non beach-front homes to designated public access points, true access is provided, not by the linear distance to the shoreline, but rather, by the network distance from each property to the nearest designated beach access point. Results from a spatial autoregressive model indicate that including a network access measure into the hedonic model not only provides a more precise indicator, and therefore, measure of access, but, as network distance can vary independently of viewshed, its inclusion can mitigate collinearity concerns, and yield more reliable amenity value coefficient estimates.

We believe that the results from our modest sample of coastal properties provide a useful insight into appropriately measuring access in restricted access communities and provide a platform for appropriately disentangling amenity values in future hedonic analyses. While the focus of this paper is on a coastal community, the implications hold for other property markets proximate to a given resource (such as ski slopes, lakes, and parks) where access is a critical issue, but not a function of the linear distance to the resource.

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