Valuing Rural Recreation Amenities: Hedonic Prices for Vacation Rental Houses at Deep Creek Lake, Maryland

Jon P. Nelson

Hedonic prices are estimated for summer and winter rentals for vacation houses located near a lake and ski-golf resort in rural western Maryland. Regressions for weekly rents are conditioned on house size, quality, and recreation features including lakefront proximity and ski-slope access. Percentage effects and marginal implicit prices indicate that access to recreation is reflected importantly in rental offers. Evaluated at the means, lakefront locations command a premium of $1,100–1,200 per week, and the premium for ski-slope access is $500–600 per week. Unit recreation values are about $18 per person per day for a lakefront location with a private dock and $7 per person per day for a ski-slope location. There are small differences in the unit values for three real estate management agencies. Although there is evidence of spatial correlation in ordinary least squares residuals, estimation of spatial-lag and spatial-error models does not yield substantial changes in the empirical results.

Key Words: recreation demand, environmental valuation, hedonic prices, spatial models

During the decade of the 1990s, rural counties with a high concentration of natural amenities and developed recreation infrastructure experienced robust economic growth, including counties located in rural Appalachia (Deller et al. 2001, Deller and Lledo 2007, Dissart and Marcouiller 2005, Johnson and Beale 2002). Although rural tourism and recreation development is sometimes viewed with mixed emotions, rising demand for recreation opportunities is essential to the continued vitality of many areas. For example, rural recreation counties experienced a 24 percent growth in employment during the 1990s, which was more than double the rate of other non-metropolitan counties. A recent USDA-ERS report examined the effects of recreation and tourism on indicators for rural employment, wages, income, poverty rates, education and health, and housing costs (Reeder and Brown 2005). For virtually all indicators, the report concluded that rural tourism and recreation contribute positively to economic and social welfare. Rapid population growth also brings challenges to public infrastructure and the environment, although the report found that crime and traffic congestion generally were not impacted adversely by growth. Only housing costs stood out as a possible negative factor, but higher rents and home prices might reflect better quality housing in rural recreation counties, rather than simply higher costs (Reeder and Brown 2005).

The development of rural recreation can involve a mixture of public and private initiatives, with the exact mix depending on the location, timing, and nature of the development. Ski areas and golf courses, for example, may be public or private. Private facilities may complement or substitute for public facilities, such as parks and lakes. For private investors, it is desirable to have indicators of the expected return from investments in facilities and accommodations for visitors. In the case of public facilities, economic evaluation of recreation development can be guided by principles of benefit-cost analysis (Hanley and Barbier 2009, Zerbe and Dively 1994), where a standard problem is the valuation of recreation demand (Bockstael, McConnell, and Strand 1991, Freeman 2003). Two nonmarket methods are typically employed: the travel cost method and stated preference surveys such as contingent valuation and conjoint analysis. As is

Jon P. Nelson is Professor Emeritus of Economics at The Pennsylvania State University, University Park, Pennsylvania. He wishes to thank the anonymous reviewers for assistance and helpful comments. Any remaining errors or omissions are the author's.

well known, the housing market and hedonic prices represent a third method for valuation of environmental resources, especially if the amenities in question are localized (Palmquist 1992). Application of this revealed preference method to recreation is less common or indirect. For example, a hedonic analysis of water clarity and property values has implications for lake-based recreation by both adjoining homeowners and visitors (Gibbs et al. 2002). Hence, hedonic property value studies can contribute to benefit-cost analysis by providing an alternative valuation or suggesting impacts that are overlooked by travel cost and contingent valuation surveys. Indeed, these latter methods, by focusing on day users and shorter-term visitors, may be prone to understatement of recreation values, since homeowners and long-term visitors may face fewer substitution opportunities and thereby place a higher value on nearby recreation amenities. Potentially, recreation valuations based on traditional methods and hedonic prices are additive, rather than substitutes.

This paper presents a hedonic analysis of proximity to lake and ski recreation amenities at a four-season resort area located in rural western Maryland. The analysis is carried out using weekly rental prices for vacation houses, rather than sales prices for residential properties. The sample consists of over 600 houses that are offered for rent through three management agencies and by private owners. There are several advantages to this particular sample. First, it can be used to evaluate recreation values for longer-term visitors, which may differ from day users and short-term visitors. Second, residential properties are heterogeneous products that trade infrequently in localized markets, which can complicate the selection of a representative sample (Knight 2008) or requires data for an extended time period. My sample includes virtually all rental houses for the peak summer and winter rental seasons during 2008. Third, it is common to argue that many homebuyers are poorly informed about market conditions, especially with respect to neighborhood disamenities, which can lead to inefficient outcomes in housing markets (Hite 1998, Pope 2008). For my sample, photos and detailed information for each house are available to prospective renters in the form of printed catalogs and through websites. Important housing characteristics and locational attributes are identified and described for each property, and terminology and maps are provided that facilitate recognition of recreation features (e.g., lakefront access, ski-in/ski-out access). Last, as noted by Wheaton (2005), there is very little published work on second home resort housing. Although the hedonic model has been applied to apartment rentals, hotel room rates, and the sale of undeveloped land near recreation facilities, only four earlier studies investigated rental prices for vacation houses in the United States (Benjamin, Jud, and Winkler 2001, Smith and Palmquist 1994, Taylor and Smith 2000, Wilman 1981 and 1984). These studies are concerned with only two eastern coastal recreation areas (Outer Banks of North Carolina, and Cape Cod and Martha's Vineyard). The importance of additional studies in this area is further highlighted by the fact that there are over 4 million seasonal homes in the United States, many of which are located in rural recreation areas (U.S. Bureau of the Census 2009, Timothy 2004).[1]

The sample of vacation houses has several other important features. First, most houses are offered for rent throughout the year, although weekly rental prices vary by time of year (peak summer, peak winter, off-season). Vacancies and infrequent rentals during peak periods are not a general problem, but in any event, rental prices are set contractually rather than negotiated. Second, the market in question is a compact geographic area, but the houses provide substantial variation in structural characteristics and locational features, which facilitates empirical analyses. Third, pricing differences among the real estate agencies can be investigated, which is rarely possible for residential housing offered through multi-list services. Overall, the empirical results reveal that proximity to recreation amenities is reflected importantly in vacation rental offers. The study provides estimates for unit recreation values, which are potential inputs for a benefit-cost analysis or returns to private investors (Palmquist 1992). There are small differences

[1] To the best of my knowledge, this is the first hedonic study to value access to ski slopes in the United States. Two related papers examine the size of ski area (length of run per ski-lift) as a determinate of tourist apartment rentals at six Swiss alpine resorts (Soguel, Martin, and Tangerini 2008) and the effect of snowfall quantity on house prices at major ski resorts in the western United States and Canada (Butsic, Hanak, and Valletta 2008).

in the derived marginal values across rental agencies.

The remainder of the paper is organized into six main sections. First, the next section reviews four prior hedonic studies of vacation house rentals. This review identifies the important features of vacation properties that were valued in these studies and comments on the present study as an extension of prior work. Several unique features of vacation rentals are examined, which distinguish them importantly from properties sold in the market for residential housing. Second, recreation opportunities are described at Deep Creek Lake, Maryland, and the Wisp Ski Resort. That section identifies features of the vacation houses, and also presents descriptive statistics for the sample. Third, empirical estimates by ordinary least squares (OLS) are presented for summer rentals. The focus in that section is the value associated with lakefront proximity and private docks. Marginal hedonic values are developed for these and other recreation amenities. Comparisons also are made with several earlier studies that value waterfront locations for residential housing. Fourth, the analysis is repeated for peak winter rentals, with a focus on the value associated with proximity to the ski slopes. Fifth, spatial correlation in the OLS estimates is examined and alternative estimates for spatial-lag and spatial-error models are provided. Sixth, conclusions from the study are presented.

Prior Studies of Vacation Rental Accommodations

The prior hedonic literature on vacation rental houses in the United States is limited to four studies for eastern coastal areas. A review of these studies is useful to identify important explanatory variables and any unique issues associated with vacation rental markets. Wilman (1981, 1984) studied monthly rental prices for a sample of tourist accommodations on Cape Cod and Martha's Vineyard for 1978. For the Cape Cod sample, accommodations were divided into four categories: (i) cottages and apartments, (ii) rented vacation houses, (iii) guesthouses and inns, and (iv) hotels and motels. For Martha's Vineyard, two categories were used: rented vacation houses and other accommodations. The purpose of the study was to estimate a two-stage hedonic model that identified inverse compensated demand functions for coastal water quality and beach quality for each type of accommodation. For Cape Cod, there are 129 rental houses in the final sample that are distributed among fifteen towns. However, measuring water and beach quality is complex (e.g., attractiveness, cleanliness, width, surf conditions), and a factor analysis is used in this study to compress thirteen variables into five factors. Beach accessibility is measured by travel time to the most frequently used beach and whether or not the accommodation has an ocean view. Characteristics of rented vacation houses are represented by only two variables: number of rooms (size) and working telephone or not (quality). A number of other housing characteristics are either statistically insignificant or missing in too many cases (Wilman 1984). Only two beach quality variables are statistically significant (beach debris, time distance to commercial centers). For Martha's Vineyard, there are only 49 rental houses that are distributed among six towns. Two accommodation variables (rooms, working telephone) and two beach-related factors (ocean view, beach visual attractiveness) are used in the final analysis. Overall, beach quality is a significant predictor of rental prices (Wilman 1984), but some of the results in the paper suggest that the samples are too heterogeneous. The present paper incorporates a larger number of housing characteristics as explanatory variables, uses a more compact geographic area for the sample, and focuses on vacation rental houses.

Smith and Palmquist (1994) studied weekly rental prices for cottages, duplex, and condominium accommodations along the Outer Banks in North Carolina for the period 1987 to 1990. The purpose of the study was estimation of people's willingness to pay for proximity to beaches depending on the timing of use (peak summer, prepeak, post-peak), while also controlling for changes in the mix of site characteristics selected at different times (e.g., air conditioning). The sample of rentals was obtained from three management firms, but composition of the sample varied over time (Smith and Palmquist 1994). Separate regressions are estimated for each year, with sample sizes ranging from 213 observations in 1987 to 963 observations in 1989. Coastal amenities are measured by proximity to the ocean (oceanfront, oceanside, sound-front) and presence of an ocean view. The other explanatory variables capture characteristics of the accommodations (e.g., number of bedrooms, bathrooms, air conditioning) and identity of the management firm. Proximity to the oceanfront has the most consistent pattern of significant results for peak versus pre-season rentals (Smith and Palmquist 1994). However, this finding did not carry over to peak versus post-season rentals. One potential limitation of this study is the pooling of several types of accommodations. The present paper also estimates hedonic functions for different rental seasons, but restricts the sample to vacation houses. Possible pricing differences for three rental seasons are considered: peak summer, late summer, and peak winter periods.

Taylor and Smith (2000) expanded the Outer Banks sample to cover the period 1987 to 1992, with the objective of testing for pricing differences among four firms that managed beach rental properties. Sample sizes varied from 132 observations for the smallest firm to 724 observations for the largest. Taylor and Smith argue that when markets are competitive, hedonic-rent functions should not be significantly different across firms. Using data from the rental booklets, they estimate firm-specific hedonic-rent functions by year and season. Explanatory variables are divided into three categories: size of accommodation (e.g., number of bedrooms, bathrooms), quality of accommodation (air conditioning, dishwasher, etc.), and location (proximity to the shoreline). Taylor and Smith obtain statistically significant results for a number of explanatory variables, including proximity variables and a variable for single houses. Using an F-test for individual coefficients, they find significant differences across firms, especially for attributes that are not easily reproduced (e.g., ocean access). As noted by the authors, their estimates are computed at different levels for other characteristics, which are "not likely to provide an equal estimate of marginal values across firms" (Taylor and Smith 2000, p. 567).[2] However, pricing strategies are relatively similar across seasons. The present paper includes fixed-effects dummies to distinguish among rental offers by three real estate management agencies. I also report separate marginal prices for selected variables for the agencies.

Benjamin, Jud, and Winkler (2001) developed a model of the weekly rent differential for smoking and non-smoking vacation houses along the Outer Banks for the peak summer season of 1998. Using a sample of 208 properties obtained from a single large realtor, the authors estimate a hedonic model with explanatory variables including size of accommodation (e.g., number of bedrooms, bathrooms), accommodation quality (age, swimming pool, air conditioning, smoking status, etc.), and location (oceanfront, semi-oceanfront, oceanside). Tests for autocorrelation indicate virtually no spatial correlation in the data. The results indicate that renters are willing to pay as much as 60 percent more per week for an oceanfront unit (Benjamin, Jud, and Winkler 2001). The premium for non-smoking units is 11.6 percent per week, but the authors anticipate that this value will decline as more units are converted to non-smoking status. In the present study, virtually all of the vacation properties fall into the non-smoking category, but I am able to investigate the effects of several other relatively new features of rental properties, including Internet access. My empirical results also reveal substantial premiums for several locational attributes, such as lakefront properties, private docks, and ski-slope locations.

The present paper incorporates a number of methodological features that occur in past studies and which are relatively unique to vacation properties. First, the paper seeks to develop estimates of the value of proximity to lake-related amenities (lakefront, split-lakefront locations). A similar analysis is presented for proximity to ski amenities (slope-side, roadside locations). Several other locational variables are considered, including dock access (private, community) and swimming pool access (private, community). The estimates are conditioned by a number of explanatory variables for housing size (bedrooms, bathrooms, bed sizes, maximum occupants) and quality attributes (central air conditioning, jetted tubs, saunas, pool table, Internet access). Following Smith and Palmquist (1994), selected results are reported for off-peak and weekend rental periods. Following Taylor and Smith (2000), pricing differences among three rental agencies are examined. Following Benjamin, Jud, and Winkler (2001), results are reported for two spatial correlation models. In contrast to several earlier studies, the sample is

---

[2] As pointed out by Day (2001, p. 3.8), in the hedonic model "it is possible for the price that is paid for each extra unit of a particular housing attribute to vary according to the level of that attribute." See also Johnston et al. (2001).

restricted to larger vacation houses that accommodate at least six persons. A few smaller cottages and all townhouses and condominiums are excluded from the sample. Last, there are important differences between residential housing markets and vacation rentals that are reflected in the sample of data and model specification. In analyses of vacation rental markets, emphasis is placed on those housing characteristics that are advertised in the rent offers, since rental can often occur on a "sight unseen" basis. As revealed in prior studies, these advertised features do not include common structural characteristics such as square footage or age of the dwelling. It would be virtually costless for management agencies to provide this additional information if it were important to potential renters. In addition, the rental price is set by contract with a sizeable down payment required, and is not negotiated. Any differences between posted list prices and the actual weekly rental price are relatively unimportant during 2008 peak periods.

Description of the Study Area and Sample

Deep Creek Lake is located in Garrett County, the westernmost county in the state of Maryland. In 2000, Garrett County had a population of 30,000 (Maryland Department of Natural Resources 2001). Much of the county is rural farmland and forested areas, and there are over 70,000 acres of state forest lands in the county. Deep Creek Lake was created in 1925 as the result of a hydroelectric power dam that was constructed by the Pennsylvania Electric Company (Penelec). At the time about 8,000 acres of farmland were acquired for the project by Penelec, with about half of the acres actually inundated by the lake. Eventually, Penelec began divesting itself of some of the real estate surrounding the lake, and over the years the area developed into a recreation region. This development was aided in the late 1980s by the completion of an interstate highway (I-68) from the east, which increased the number of visitors from the Baltimore and Washington, D.C., population centers. In 1980, the state of Maryland agreed to take over management of recreation and access at Deep Creek Lake. In 2000, General Public Utility, Penelec's holding company, negotiated the sale to the state of Maryland of the lake bottom, a buffer zone around the lake, and certain other land parcels owned by the power company. The sale price was $17 million. The state immediately passed legislation creating a Deep Creek Lake Policy and Review Board (PRB). In 2001, the PRB and the Maryland Department of Natural Resources (MDNR) issued a management plan for the lake that regulates water quality, shoreline and buffer areas, adjacent land use, zoning, visitor access, commercial uses, recreation areas, and recreation activities (MDNR 2001). Building of permanent structures within the buffer strip is prohibited, and non-permanent structures (e.g., decks, paths, fire-pits) and cutting of trees require a permit from the MDNR. The lake is 12 miles in length and has a shoreline of about 65 miles covering 3,900 acres. The convoluted shoreline is heavily wooded, and much of the lake is surrounded by low mountains and other wooded areas. The lake is the center of popular water-based recreation activities, including power boating, fishing, lake kayaking, waterskiing, wakeboarding, tubing, jet skiing, windsurfing, and sailing. Most lake-based swimming occurs at a public beach at Deep Creek Lake State Park [see Deep Creek Times (2009)].

The second recreation focal point is the Wisp Resort, a privately operated ski and golf resort located in McHenry, Maryland, at the northern tip of Deep Creek Lake. The resort is located within a three-hour drive from Baltimore and Washington, D.C., two hours from Pittsburgh, and four hours from Philadelphia and Richmond. The ski area began operation in the mid-1950s as a local ski area, with the first major expansion occurring in the early 1970s when more trails were opened and snowmakers, lights, and chairlifts were installed (Bell 2007). In 1981, Wisp Resort opened an 18-hole golf course and began billing itself as the only four-season resort in Maryland. In 1994, developers purchased 2,400 acres of land adjacent to Wisp. At the time, construction of vacation accommodations was focused on condominiums and townhouses. In 2001, DC Development LLC purchased Wisp for $12 million and initiated a series of capital improvement projects that now total $30 million, including expenditures on additional slopes and trails, larger chairlifts, and snowmaking equipment (Bell 2007). The ski area presently has 32 trails (10.5 miles, 132 acres) and a maximum vertical drop of 700 feet. There are seven chairlifts (2 quads, 5 triples), two ski carpets, and four surface tows. The lift capacity is 12,600 persons per hour. In 2007, an artificial whitewater kayaking and rafting course was opened on the mountain top, which employs the water reservoir used for snowmaking in the winter season. The resort also offers a variety of other seasonal recreation activities, including golf, tennis, mountain biking, rock climbing, horseback riding, fly-fishing, mountain coaster rides, paintball, snowboarding, snowtubing, and Nordic skiing. A wide variety of supporting commercial facilities and other recreation services have been constructed in the vicinity of the lake and resort (see the websites in the Data Appendix). However, there are relatively few motels or hotels in the immediate vicinity of the lake and resort.

Beginning in the 1990s, construction of accommodations near the lake shifted from townhouses to modern vacation houses, with sizeable bedrooms, multiple decks, hot tubs, and other features. These structures tended to be much larger than earlier single-family homes and cottages (MDNR 2001). Further, the newer houses tend to be used throughout the year, rather than seasonally. As of 2007, there were about 2,500 homes in the Deep Creek Lake watershed (Bell 2008), but not all of these are rentals. Three real estate management agencies specialize in renting vacation properties, and these agencies' catalogs and websites were the main source of data for this study (see the Data Appendix). The sample includes a variety of data on size and quality of accommodations, rental prices for three seasonal periods (summer peak, winter peak, late summer), and location features of the houses, including the latitude and longitude. The variables and data sources are described in the Data Appendix. The full sample for the summer season has 610 observations. Rental Agency A is largest, with 312 vacation houses, followed by Agency B (157 houses) and Agency C (91 houses). There are 50 vacation-rental-by-owner (VRBO) houses in the full sample, but information on the exact street address for these properties is missing. The winter sample has 577 observations.

Table 1 displays selected features of the rental houses for the full sample, each management agency, and the VRBO properties. The mean house in the full sample has 4.5 bedrooms, 4 bathrooms, and a maximum occupancy of 12 persons. There are 286 houses (47 percent) that have lakefront access and 64 houses (11 percent) that have ski-slope access. The summary indicates that Agency A's properties are somewhat larger (5 bedrooms, 13 occupants) and have higher rental prices on average. Each of the management agencies offers its properties for most of the year, and the rental catalogs report a variety of list prices. There are weekly, weekend, and extra night prices for as many as seven seasonal periods: early summer (mid-June to July), peak summer (July to mid-August), late summer (mid-August to Labor Day), fall (Labor Day to mid-October), out of season (mid-October to mid-December), peak winter (mid-December to mid-February), extended winter (mid-February to mid-March), and spring (mid-March to mid-June). However, rental prices do not necessarily vary across all time periods; e.g., the peak summer and late summer rates are sometimes the same. Some properties are not available on a year-round basis, and weekend (2-night) rentals are not offered during the peak summer period. In order to facilitate the analysis, rental prices were obtained for peak summer (weekly only), late summer (weekly, weekend), and peak winter (weekly, weekend) periods for the year 2008. Table 1 reports relative price ratios for selected time periods. Winter rental rates are about 85 percent of the peak summer rate, while the late summer rate is about 90 percent of the peak summer rate. Weekend rates are about 50 percent of the weekly rate for both summer and winter. The empirical analysis concentrates on the peak weekly rates for summer and winter, but selected results are reported for the late summer period and weekend winter rentals. It is important to note that this is not a study of the effect of a view on rental values. Due to the convoluted heavily wooded shoreline, lake views are often obscured or partially blocked for at least part of the year. All of the management agencies are careful to point this out in their rental catalogs.

The agency rental catalogs (and maps) are organized according to location categories for lake and ski access, and the catalogs define several location-related terms. Most of this information, including the agency maps, also is available on the websites (see the Data Appendix). Eleven location variables were created based on this information. These variables are summarized in Table 2, along with average rental prices for the properties in each category. For example, the median summer rent for lakefront properties is $3,095 per week, compared to a median of

Table 1. Means, Standard Deviations, and Counts for Selected Variables

Variable	Total Sample	Agency A	Agency B	Agency C	VRBO
Summer rent ($)	2637 (1484)	3177 (1649)	2291 (1095)	1672 (821)	2108 (896)
Late summer ($)	2420 (1411)	2948 (1579)	2058 (1002)	1485 (703)	1967 (886)
Winter rent ($)	2178 (1297)	2518 (1513)	1992 (877)	1402 (645)	1884 (972)
Winter weekend ($)	1081 (618)	1214 (719)	998 (463)	800 (335)	956 (487)
Occupants (no.)	12.2 (4.1)	13.2 (4.5)	11.7 (3.6)	9.9 (2.8)	11.3 (2.7)
Bedrooms (no.)	4.5 (1.4)	4.8 (1.4)	4.3 (1.2)	3.8 (0.9)	4.2 (1.1)
Bathrooms (no.)	3.7 (1.5)	4.0 (1.6)	3.6 (1.3)	2.8 (1.0)	3.5 (1.1)
Lakefront (no.)	286	174	70	25	17
Split-lakefront (no.)	24	7	6	11	0
Slope-side (no.)	64	28	31	1	4
Road-side (no.)	33	27	5	1	0
Winter-summer rent ratio	0.84 (0.19)	0.79 (0.17)	0.90 (0.22)	0.86 (0.12)	0.88 (0.18)
Late summer-summer rent ratio	0.91 (0.05)	0.92 (0.04)	0.90 (0.03)	0.89 (0.05)	0.93 (0.08)
Winter weekend rent ratio	0.50 (0.06)	0.48 (0.04)	0.50 (0.05)	0.58 (0.05)	0.51 (0.07)
Late summer weekend rent ratio	0.50 (0.06)	0.48 (0.05)	0.48 (0.05)	0.57 (0.05)	0.49 (0.06)
Summer sample N	610	312	157	91	50
Winter sample N	577	301	149	77	50

Notes: Means are computed for the summer sample for the three size variables and number of lakefront and split-lakefront properties; standard deviations are in parentheses. Slope-side and road-side counts are for the winter sample. The late summer and winter weekend ratios are ratios of the weekend rental price (2 nights) to the weekly rental price (7 nights). The weekly ratio sample sizes are 571 observations for winter and 610 observations for late summer. Similar procedures were followed for each agency's means and the weekend ratios. See Table 2 and the Data Appendix for additional information on the variable definitions and data sources.

$1,842 for lake-access properties. The difference is $1,253 per week. For winter rentals, houses nearest to the ski slope have a median rental of $2,308 per week, compared to $1,750 for non-access houses, which is a difference of $558 per week. On average, these differences correspond closely to the mean implicit prices derived from the hedonic regressions, which is noteworthy in terms of the robustness of the estimated models.

Empirical Results for Summer Rentals

This section estimates a semi-logarithmic hedonic price model for summer rentals for a sample of 610 houses. The estimated coefficients can be used to obtain implicit prices for structural characteristics, quality attributes, and location features of the vacation houses. Following Kennedy (1981) and van Garderen and Shah (2002), the coefficient estimates are transformed to obtain percentage effects, and the percentages are evaluated at the sample means to obtain marginal implicit prices for 2008. In addition, selected results are reported for late-summer rentals, and comparisons are made with several prior empirical studies of waterfront proximity for residential properties.

Let R_{im} represent the weekly rental price of the ith property offered by the mth rental agency (m = Agency A, B, C, or VRBO), X is a vector of continuous variables that describe the size of the

Table 2. Description of Locational and Agency Binary Variables

Variable	Description
Lakefront	The property borders the buffer zone around the lake. "Lakefront" means that the renter has direct access to the water and can go directly to the lake without crossing a road. Most lakefront homes have access to a private dock or a dock slip at a community dock or marina. Lakefront does not necessarily mean that the property has a view of the lake because much of the shoreline is wooded. There are 286 lakefront houses in the sample. Mean (s.d.) weekly summer rent is $3,408 (1587); median, $3,095. Mean (s.d.) weekly late summer rent is $3,129 (1528), median, $2,793.
Split-lakefront	The property borders on the buffer zone, but there is a road between the house and the water. The property owner owns the land on both sides of the road bordering the buffer zone. Split-lakefront houses do not necessarily have a view of the lake. There are 24 split-lakefront houses. Mean (s.d.) weekly summer rent is $1,903 (569); median, $2,060.
Lake access	The property has a deeded access place to reach the water, and in some cases boat docks, but the property owner does not own the access area. The renter may or may not be able to walk to the water. The property may or may not have a view of the lake. There are 212 lake access houses. Mean (s.d.) weekly summer rent is $2,059 (1040); median, $1,842. Included in final model in the constant term.
Lake area	This term refers to all other properties in the surrounding Deep Creek Lake area. The property may or may not have a view of the lake. There are 88 lake area houses. Mean (s.d.) weekly summer rent is $1,722 (835); median, $1,571. Included in final model in the constant term.
Ski-slope access	Ski-in/ski-out properties are located near the Wisp Resort and are within walking distance of the ski slopes (550 yards or less). There are 64 ski-slope access houses. Mean (s.d.) weekly winter rent is $2,684 (1320); median, $2,308. Mean (s.d.) weekend winter rent is $1,401 (672); median, $1,195. The weekly mean (s.d.) value for 480 non-access properties is $2,071 (1250); median, $1,750.
Ski-road access	The property is located on Marsh Hill Road, which leads directly to the ski slopes, but are not within walking distance of a ski lift. There are 33 ski-road access houses. Mean (s.d.) weekly winter rent is $2,749 (1560); median, $2,195.
Private dock	House has access to a private dock. There are 201 houses with access to a private dock. Mean (s.d.) weekly summer rent is $3,061 (1548); median, $2,750. Mean weekly late summer rent is $2,812 (1499); median, $2492.
Dock slip	House has access to a free dock slip at a community dock or marina. There are 229 houses with access to a dock slip. Mean (s.d.) weekly summer rent is $2,896 (1563); median, $2,322.
Private pool	There are 32 houses with private swimming pools (30 of 32 are indoor pools). Mean (s.d.) weekly summer rent is $6,022 (1925); median, $5,695. Mean (s.d.) weekly late summer rent is $5,724 (1863); median, $5,206.
Community pool	There are 27 houses with access to an indoor community swimming pool. Mean (s.d.) weekly summer rent is $2,628 (1115); median, $2,322.
Public golf	Due to the compact size of the Deep Creek Lake area, all rental houses in the sample were considered to be within a 10–15 minute drive of the public golf course at Wisp Resort. Consequently, a separate dummy variable was not created for public golfing access.
Private golf	Waterfront Greens is a gated housing subdivision adjacent to Deep Creek Lake. It has a private par-3 golf course. There are only 28 rental houses in the sample with access to a private golf course. Mean (s.d.) weekly summer rent is $3,720 (1777); median, $3,847. Not included in final model.
Agency variables	Dummy binary variables for Agency A, B, and C. The VRBO rentals are in the constant term. Only the significant agency dummies are retained in some regressions.

Notes: See Table 1 and the Data Appendix for additional information on the variables. The information in this table is based in part on descriptions in the 2008 rental catalogs of the three real estate management agencies.

property, Y is a vector of dummy variables for the quality of the property, and Z is a vector of dummy variables for location attributes. Omitting time subscripts, the semi-log hedonic regression model is written as

(1)
$$\log(R_{im}) = a + \sum_{j=1}^{J} b_j x_{ij} + \sum_{k=1}^{K} c_k y_{ik} + \sum_{l=1}^{L} d_l z_{il} + \delta_m + u_{im} ,$$

where a is the constant term, b, c, and d are coefficients, δ is an agency-specific intercept, and u is a stochastic error term assumed to be identically and independently distributed with a mean of zero and uniform variance. The agency intercepts capture unobserved fixed-effects, such as management services and firm-specific vacancies.[3] The regression model in this section is estimated by OLS with coefficient standard errors obtained using White's heteroskedastic-consistent estimator. In order to investigate broad differences among the three rental agencies, results are reported for three regressions for peak summer and peak winter rentals: (i) all rentals, with binary dummies for the three management agencies, (ii) all rentals, with only the significant agency dummies retained, and (iii) an agency sample (no VRBOs), with only the significant agency dummies retained.

A variety of potential explanatory variables were collected for size, quality, and location of the properties for 2008 (see Table 2 and the Data Appendix). In order to reduce the number of variables to a potentially important set, collinearity among the variables was investigated using simple correlations and variance inflation factors (VIF). Some of the simple correlations are high among the size-related variables (e.g., occupants and bedrooms) and the lake and dockage variables. However, the VIF calculations in the Data Appendix suggest that these correlations are not troublesome in a multivariate context. The main data problem is the large number of quality variables and, in some cases, the category sample sizes are very small, e.g., only 11 houses have more than one hot tub. In the interest of parsimony, the models for the summer sample include four size-related variables (maximum occupants, bedrooms, bathrooms, percentage king-size beds), six quality-related variables (central air conditioning, jetted tubs, extra fireplaces, pool table, extra TV sets, Internet access), and six location-related variables (lakefront, split-lakefront, private dock, dock slip, private pool, community pool access).

The empirical results for the summer sample are shown in the first three regressions in Table 3. Examining the first regression, all of the explanatory variables have the expected positive sign and are statistically significant, except the dummy for extra TV sets. Only the dummy for Agency A is significant, so the other agency dummies are deleted in regressions (2) and (3). The coefficient magnitudes and standard errors are quite stable across the three regressions. The coefficients for Agency A are significantly positive in regressions (2) and (3). Dropping the VRBO houses in regression (3) increases the size of the lakefront dummy. The magnitude of the locational coefficients is substantial for lakefront proximity, private pool, private dock, community pool, and split-lakefront access. It is interesting to note the consistency of magnitudes between some of the regressors: (i) an extra bedroom is valued more than an extra bathroom, (ii) lakefront proximity is valued more than a split-lakefront location, (iii) a private dock is valued more than a dock slip, and (iv) a private pool is valued more than access to a community pool. The adjusted R-squares are quite high, with values of 0.910 and 0.917 for regressions (2) and (3), respectively. The regression standard errors are only 2 percent of the mean of the dependent variable, indicating that the summer regressions perform well in a predictive sense for the overall weekly rental values.

In order to further evaluate the results, percentage effects and marginal implicit prices were calculated for all variables. In the interest of space, marginal values are reported for three continuous variables (occupants, bedrooms, bathrooms) and seven dummy variables (lakefront, split-lakefront, private dock, dock slip, private pool, community pool, and Agency A). The percentage effects were then evaluated at the mean rent in order to obtain marginal implicit prices for regressions (2) and (3). Table 4 displays the results of these calculations, including the standard errors for percentage effects. The largest percentage effect is lake-

[3] Vacancy rates by rental property are not observed. During the data collection phase in 2008, there was very little online discounting, which is more important during off-peak periods. The actual occupancy number by property also is not observed, so the marginal willingness-to-pay values reported here are minimum or lower-bound estimates.

Table 3. OLS Regression Results: Weekly Peak Summer and Peak Winter Rentals

Variable	(1) Summer: Full Sample	(2) Summer: Full Sample	(3) Summer: No VRBOs	(4) Winter: Full Sample	(5) Winter: Full Sample	(6) Winter: No VRBOs
Constant	6.4208 (0.036)*	6.4171 (0.026)*	6.4161 (0.027)*	6.2913 (0.036)*	6.2904 (0.026)*	6.2888 (0.028)*
Occupants (no.)	0.0178 (0.004)*	0.0178 (0.004)*	0.0188 (0.004)*	0.0190 (0.004)*	0.0185 (0.004)*	0.0185 (0.004)*
Bedrooms (no.)	0.0717 (0.012)*	0.0720 (0.012)*	0.0638 (0.012)*	0.1014 (0.013)*	0.1034 (0.013)*	0.1009 (0.013)*
Bathrooms (no.)	0.0626 (0.009)*	0.0618 (0.009)*	0.0628 (0.009)*	0.0718 (0.009)*	0.0697 (0.009)*	0.0718 (0.009)*
King-size beds (%)	0.0006 (0.0003)*	0.0006 (0.0003)*	0.0005 (0.0003)	0.0007 (0.0003)*	0.0008 (0.0004)*	0.0007 (0.0004)
Lakefront	0.3535 (0.019)*	0.3562 (0.019)*	0.3648 (0.020)*	0.1784 (0.016)*	0.1871 (0.016)*	0.1947 (0.017)*
Split-lakefront	0.1220 (0.042)*	0.1182 (0.041)*	0.1149 (0.042)*	---	---	---
Private dock	0.1523 (0.026)*	0.1512 (0.026)*	0.1705 (0.027)*	---	---	---
Dock slip	0.0860 (0.017)*	0.0867 (0.017)*	0.0961 (0.018)*	---	---	---
Ski-slope access	---	---	---	0.2364 (0.028)*	0.2500 (0.027)*	0.2430 (0.028)*
Ski-road access	---	---	---	0.0656 (0.021)*	0.0714 (0.022)*	0.0659 (0.022)*
Private pool	0.3087 (0.036)*	0.3058 (0.037)*	0.2920 (0.039)*	0.2965 (0.038)*	0.2960 (0.038)*	0.2832 (0.041)*
Community pool	0.1327 (0.0252)*	0.1330 (0.025)*	0.1427 (0.027)*	0.0681 (0.027)*	0.0748 (0.027)*	0.0778 (0.027)*
Central AC	0.1140 (0.018)*	0.1160 (0.018)*	0.1327 (0.017)*	---	---	---
Jetted tub	0.0402 (0.014)*	0.0476 (0.013)*	0.0391 (0.013)*	0.0130 (0.016)	0.0261 (0.015)	0.0243 (0.016)
Sauna	---	---	---	0.0712 (0.027)*	0.0741 (0.026)*	0.0604 (0.028)*
Extra fireplace	0.0455 (0.013)*	0.0499 (0.013)*	0.0524 (0.013)*	0.0460 (0.017)*	0.0524 (0.016)*	0.0598 (0.017)*
Pool table	0.0838 (0.015)*	0.0808 (0.014)*	0.0856 (0.015)*	0.0888 (0.017)*	0.0863 (0.017)*	0.0898 (0.018)*
Extra TVs	0.0170 (0.015)	0.0199 (0.015)	0.0195 (0.015)	0.0299 (0.018)*	0.0357 (0.018)*	0.0378 (0.019)*
Internet access	0.0689 (0.018)*	0.0641 (0.017)*	0.0624 (0.019)*	0.0565 (0.020)*	0.0598 (0.016)*	0.0630 (0.017)*
Agency A houses	0.0945 (0.027)*	0.0944 (0.016)*	0.0948 (0.018)*	0.0253 (0.028)	---	---
Agency B houses	0.0166 (0.029)	---	---	0.0293 (0.030)	---	---
Agency C houses	-0.0282 (0.036)	---	---	-0.0437 (0.037)	---	---
Adjusted R-sq	0.911	0.910	0.917	0.888	0.887	0.893
Sample N	610	610	560	577	577	527
Mean rent ($)	2637	2637	2684	2178	2178	2206

Notes: Dependent variable is log of weekly rent for 2008; White's heteroskedastic-consistent standard errors are in parentheses. Asterisks indicate statistically significant coefficient at the 95 percent confidence level.

Table 4. Percentage Effects and Marginal Implicit Prices

Variable	(1) Summer: Full Sample	(2) Summer: No VRBOs	(3) Agency A	(4) Agency B	(3) Winter: Full Sample	(4) Winter No VRBOs
Occupants (no.)	1.78 (0.4) $47	1.88 (0.4) $50	1.17 (0.4) $37	2.40 (0.6) $55	1.85 (0.4) $40	1.85 (0.4) $41
Bedrooms (no.)	7.20 (1.2) $190	6.38 (1.2) $171	8.75 (1.3) $278	7.27 (2.1) $167	10.34 (1.3) $225	10.09 (1.3) $223
Bathrooms (no.)	6.18 (0.9) $163	6.28 (0.9) $169	5.43 (0.9) $172	4.55 (1.5 $104	6.97 (0.9) $152	7.18 (0.9) $158
Lakefront	42.77 (2.8) $1128	44.00 (2.8) $1181	48.56 (3.1) $1543	35.35 (6.1) $810	20.56 (1.9) $448	21.48 (2.0) $474
Lakefront—late summer rentals	41.61 (2.8) $1007	42.85 (2.8) $1055	46.38 (3.0) $1367	35.57 (6.2) $732	---	---
Split-lakefront—peak summer	12.45 (4.6) $328	12.08 (4.7) $324	8.66 (8.6) $275	3.31 (7.9) $76	---	---
Ski-slope access—peak winter	---	---	21.84 (4.3) $550	32.49 (5.8) $647	28.36 (3.5) $618	27.46 (3.5) $606
Ski-slope access—winter weekend	---	---	30.10 (5.9) $365	40.46 (7.2) $404	31.96 (4.4) $346	30.62 (4.4) $334
Ski-road access—peak winter	---	---	7.96 (2.1) $200	12.75 (4.7) $254	7.37 (2.3) $161	6.79 (2.3) $150
Ski-road access—winter weekend			10.18 (2.5) $124	7.27 (6.4) $73	6.74 (2.6) $73	6.47 (2.7) $71
Private dock—peak summer	16.28 (3.1) $429	18.54 (3.1) $498	12.21 (3.4) $388	30.17 (7.8) $691	---	---
Private dock—late summer	16.31 (3.1) $394	18.99 (3.1) $467	13.49 (3.3) $398	29.79 (7.8) $613		
Dock slip	9.04 (1.8) $238	10.07 (2.0) $270	6.45 (2.4) $205	17.93 (4.3) $411	---	---
Private pool	35.69 (5.0) $941	33.80 (5.2) $907	35.48 (5.4) $1127	63.76 (7.7) $1461	34.35 (5.1) $748	32.62 (5.4) $720
Community pool	14.18 (2.9) $374	15.30 (3.1) $411	15.29 (3.4) $486	15.60 (7.1) $357	7.73 (2.9) $168	8.05 (3.0) $178
Agency A houses	9.88 (1.7) $261	9.93 (1.9) $266	---	---	---	---
Avg. summer rent	2637	2684	3177	2291	---	---
Avg. winter rent	---	---	2518	1992	2178	2206

Notes: For each variable, percentage values and standard errors (in parentheses) are in the first row and marginal dollar values in the second row. Dollar values are calculated at 2008 sample means (in last two table rows). Values for late summer rentals and weekend winter rentals are from separate unreported regressions. Values for Agencies A and B are for unreported regressions for peak summer rentals, except for the late summer and winter values. Calculations of percentage effects and standard errors for the dummy variables in a semi-log model follow Kennedy (1981) and van Garderen and Shah (2002). Full results are available upon request from the author.

front proximity: 42.8 percent and 44.0 percent in columns 1 and 2, respectively.[4] This yields lakefront premiums of $1,128 and $1,181 per week. A private dock is valued between $429 and $498 per week. Focusing on the results in column 2, a marginal increase in the number of occupants is worth $50 per week; an additional bedroom, $171; and an additional bathroom, $169. For the housing quality variables, a private pool is worth $907 per week. The other locational attributes also have substantial values. For example, a split-lakefront is worth $324 per week; dock slip, $270; and access to a community pool, $411.

Three extensions of the summer model are obtained. First, in order to examine pricing over the summer season, additional regressions were estimated for the late summer period, and the percentage effects and marginal values are reported in Table 4 for lakefront access only (full results available upon request). The value of this amenity is worth $121 to $126 less during the late summer rental season. An examination of the combined value of lakefront and private dock access indicates that late summer value is about 90 percent of the peak summer value. Second, the marginal prices in Table 4 can be scaled to represent prices per unit of recreation. For example, the price for lakefront access is $1,181 per week, or $169 per day. The mean number of occupants for lakefront houses is 13 per house, so the average daily value per person is $13.[5] Including the marginal value of a private dock ($498) raises the unit value to $18 per person per day. Third, separate regressions were estimated by rental agency. Table 4 summarizes selected results for the summer periods for Agencies A and B. For lakefront access with a private dock, the lower-bound marginal value during the peak period is $20 per person per day for Agency A and $17 for Agency B. The value for Agency C is $22 per person per day. There are several possible explanations for the differences observed across rental agencies. First, there can be unobserved firm-differences that are correlated with included variables, such as size of lake frontage, visual effects, and neighborhood effects. Second, there can be market power effects, reflecting the ability of each agency to extract contractural rents from the property owners (Taylor and Smith 2000). Third, the differences may indicate that the marginal price schedule is non-linear, especially for housing characteristics that cannot easily be reproduced or repackaged. Each agency is observed at a slightly different point along this schedule, reflecting differences in the sample of houses that it manages (Taylor and Smith 2000).[6]

Empirical Results for Winter Rentals

This section estimates a semi-logarithmic hedonic price model for winter rentals for a sample of 577 houses, including 64 slope-access (ski-in/ski-out) houses and 33 ski-road access houses (Marsh Hill Road location). The OLS estimates are used to obtain percentage and implicit prices for structural characteristics, quality attributes, and location attributes. In addition, selected results are reported for weekend winter rentals. The estimation procedures used in this section parallel those used for peak summer rentals, except that some variables are omitted from consideration (air conditioning, dock access, split-lakefront). A dummy variable is included for saunas. Lakefront proximity was included as an explanatory variable to reflect any fixed-effects associated with these properties. Results again are reported for three regressions, using different specifications for the agency dummies.

[4] As a further test, the lakefront premium in the present study can be compared to values obtained from prior studies of residential property values. Geoghegan, Wainger, and Bockstael (1997) found a waterfront premium of 37 percent (author's calculation) for the Washington, D.C., area for 1990. Rush and Bruggink (2000) found a premium for oceanfront properties of $175,800 ($225,400 in 2008$) at Long Beach Island, New Jersey, which is 49 percent of the mean price. Benjamin, Jud, and Winkler (2001) reported an oceanfront premium of 60 percent for vacation rental houses on the Outer Banks. Bond, Seiler, and Seiler (2002) found a lakefront premium for Lake Erie of $256,500 ($315,600 in 2008$), which is 49 percent of the mean price. Hence, the lakefront premium of 43–44 percent derived for Deep Creek Lake is within the range of several earlier studies. I also examined the prices for January 2009 for undeveloped lakefront lots and lake-access lots offered for sale by an agency. The mean price for 19 lakefront lots was $375,000 per quarter-acre, while the mean price for 21 lake-access lots was $100,000, implying a lakefront premium of about $275,000 per quarter-acre.

[5] I also tried estimating a model with an interaction term between the maximum number of occupants and the dummy variable for lakefront location. However, the interaction variable was insignificant.

[6] I used the separate results to predict the weekly summer rental for an average-sized house in the sample (Table A1 in the Data Appendix) with a lakefront location, private dock, central air-conditioning, an extra fireplace, and pool table. The predicted rent for Agency A was $3,082; Agency B, $3,069; and Agency C, $3,074. The results suggest that while some characteristics are priced differently, rents for comparable houses are very similar across agencies.

In Table 3, regressions (4)–(6) display the empirical results for peak winter rentals for 2007–2008. In regression (4), all coefficients for the explanatory variables are significantly positive, except for the dummy for jetted tubs. None of the agency fixed-effects are significant, and these variables are omitted in regressions (5) and (6). The three largest locational coefficients are private pool, ski-slope access, and lakefront proximity. The adjusted R-squares are 0.887 and 0.893 for regressions (5) and (6), respectively. The regression standard errors are about 2 percent of the mean of the dependent variable, indicating that the winter regressions perform well in a predictive sense for the overall weekly rental values. Again, the coefficient magnitudes and standard errors are quite stable across the three regressions.

Table 4 displays the results for percentage effects and marginal dollar values for peak winter rentals. Using the last two columns, the percentage premium for ski-slope proximity is between 27 percent and 28 percent; ski-road access, 7 percent; lakefront proximity, 21 percent; and private pool access, 33–34 percent. The marginal implicit prices in column 4 are ski-slope access, $606 per week; ski-road access, $150; lakefront proximity, $474; and private pool access, $720. Selected results also are reported for weekend winter rentals, but it is more interesting in this case to examine the percentage effects compared to weekly rentals. For ski-slope access, the weekend premium is about 31–32 percent, which exceeds the weekly premium of 27–28 percent. Dollar-wise, the weekend premium is $334 to $346, or about 55–56 percent of the weekly values. In Table 1, weekend rates are about 50 percent of the weekly rate. Because weekend skiers are likely to want to maximize the time spent on the slopes, the ski-access premium gets reflected in the relatively higher weekend rates for slope-side houses. Overall, the value of proximity to the ski slopes is substantial for both weekly and weekend winter rentals. Examining the other variables for the winter sample, a marginal increase in the number of occupants is worth $41 per week; an additional bedroom, $223; and an additional bathroom, $158. For the housing quality variables, a community pool is worth $178 per week. Reflecting lower average weekly rates in the winter, most of these values are smaller than their comparable summer values. In general, the summer/winter differences are revealing of a market where housing characteristics are priced differently at different times during the year. This replicates findings reported in Smith and Palmquist (1994) and Taylor and Smith (2000).

Two extensions of the model and results are obtained. First, the marginal value can be expressed as a unit value for recreation access. The hedonic price of $606 per week for slope-side access is equivalent to a unit value of about $7 per person per day. The weekend price of $334 is equivalent to $13 per person per day. Second, separate regressions again were estimated by agency, and selected results are summarized in Table 4 for the winter periods for Agency A and Agency B. At the means, slope-side access for Agency A's houses is valued at $550, or about $6 per person per day. Slope-side access for Agency B is $647, or $7 per person per day. Agency C managed only one slope-side property and is omitted. Again, the small differences observed by agency can reflect several possible effects.

Sensitivity Analysis: Spatial Regression Estimates

As a sensitivity analysis, this section estimates hedonic price models for peak summer and peak winter rentals that correct for spatial autocorrelation. Three questions are addressed. First, are spatial effects present in the data for weekly rentals? Test results are reported for Moran's I and Geary's C statistics. Second, if evidence of spatial effects is uncovered, which spatial model is best? Maximum likelihood estimates are provided for the spatial-lag model and the spatial-error model for both time periods. Third, given a preferred model, how do the spatially corrected estimates compare to the OLS estimates and values reported in Tables 3 and 4? Comparisons are presented for the percentage effect for each variable in the regressions for the agency sample. VRBO properties are omitted in this section due to missing data on the exact addresses of these houses. The sample sizes are 560 and 527 observations for summer and winter, respectively.

The use of spatial econometrics for hedonic models began twenty years ago with the publication of papers by Can (1990) and Dubin (1988). Surveys of the literature are available in Anselin (2003), Bowen, Mikelbank, and Prestegaard (2001), Dubin (1998), and LeSage and Pace (2009). Spatial correlation can arise for at least two reasons. First, there may be spatial-lag or autoregressive effects in the dependent variable. For example, neighborhood spillovers may occur due to the tendency for houses in subdivisions to share common features, creating spatial heterogeneity across subdivisions. In the spatial-lag model, the indirect effects of these features are incorporated through spatially weighted averages of "nearby" prices. Spatially lagged dependent variables result in positively biased OLS estimates (LeSage and Pace 2009). Second, the stochastic errors can be autocorrelated due to omitted variables or other measurement errors that are correlated across space (e.g., lot dimensions, age of dwelling, better views), creating spatial-error dependence. In the most likely scenario of positive spatial correlation, OLS estimates are inefficient and the estimated standard errors are biased downward (LeSage and Pace 2009).

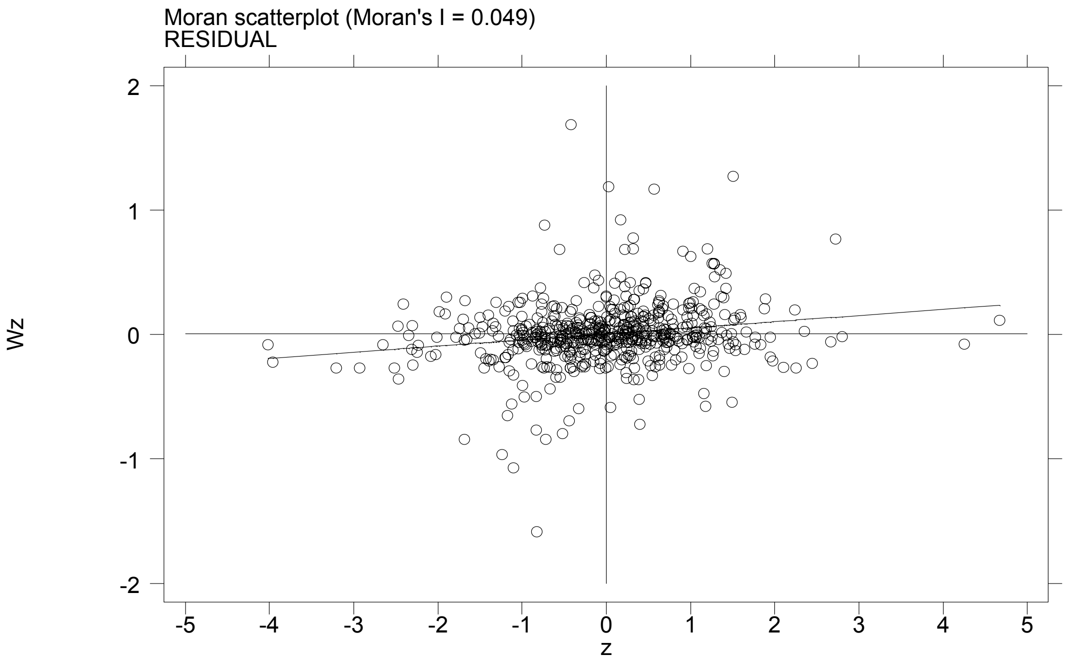
The present paper estimates by maximum likelihood (ML) the spatial-lag and spatial-error models using weights matrices based on distance bands. Tests were first conducted for spatial correlation using the OLS residuals from regressions (3) and (6) in Table 3 for peak summer and peak winter rentals, respectively. Values were calculated for the global Moran's I statistic and Geary's C statistic for two distance bands (400m, 600m). In all cases, there is evidence of positive spatial correlation. Using the 400m bands, Figure 1 displays Anselin's Moran scatterplots for the local z-scores. Greater dispersion is evident in the scatterplot for the winter rentals. While the diagrams demonstrate positive autocorrelation, many of the values are clustered around zero, and it may be that a few outliers in the upper right and lower left quadrants are responsible for the test results (i.e., the OLS residuals are close to normally distributed, except for a few outliers). This inference is supported by the ML regression results reported below.

Using the weights based on 400m bands, Table 5 shows the ML estimates for peak summer and peak winter rentals for the agency sample. In columns 3 and 6, numerical comparisons with the OLS estimates are reported by using the percentage effects and standard errors for each explanatory variable. The first thing to observe is that there are a few minor changes in the significance of the explanatory variables. In column 3 of Table 3, the insignificant OLS variables are percentage king-size beds and the dummy for extra TV sets. In columns 1 and 2 of Table 5, the insignificant ML variables also are percentage king-size beds and the dummy for extra TV sets. In column 6 of Table 3, the insignificant OLS variables are percentage king-size beds and the dummy for jetted tubs. In columns 4 and 5 of Table 6, the insignificant ML variables are these two variables and the dummy for ski-road access. The second observation is that the autoregressive parameters (rho) in Table 5 are insignificant for the spatial-lag model, while the autocorrelation parameters (lambda) are statistically significant in columns 2 and 5 for the spatial-error model. The log-likelihood values also are greater for these latter regressions. Hence, the preferred model for both summer and winter rentals is the spatial-error model.

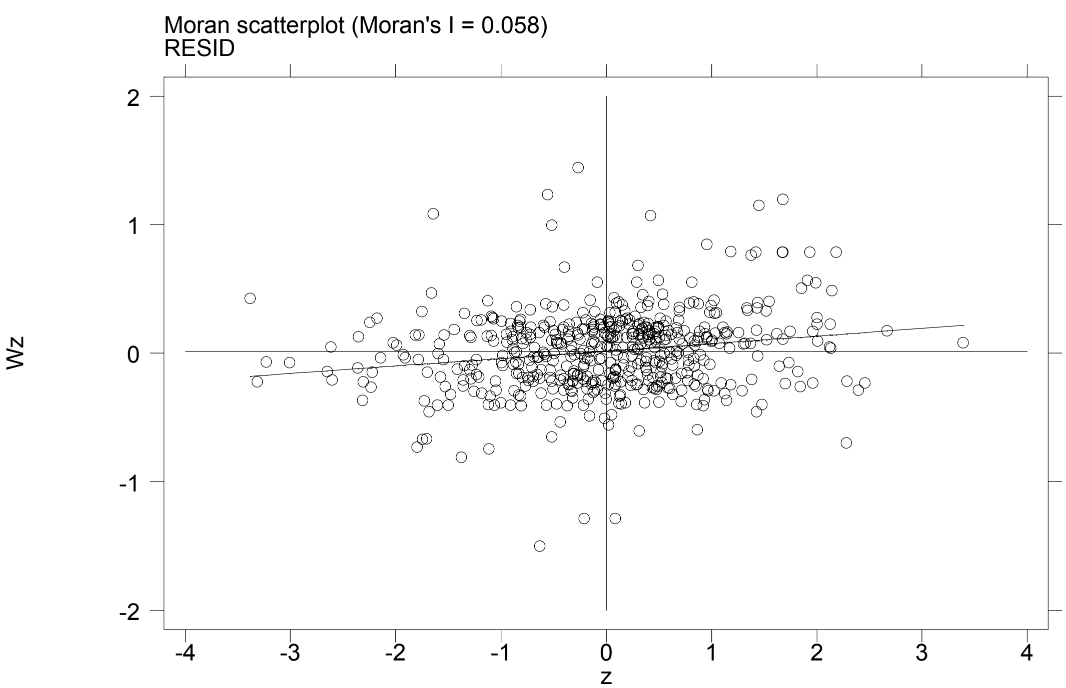
In Table 5, columns 3 and 6 present numerical comparisons for percentage effects and standard errors for the OLS estimates versus the spatial-error estimates. For the most part, the differences are minor. For example, in column 3, the lakefront premiums are 44.0 and 44.1 percent for OLS and ML, respectively, and the implicit prices for lakefront proximity are $1,181 and $1,185. The standard errors are not changed in any substantial manner. The spatial regressions for winter rentals display somewhat greater changes in coefficient magnitudes. In column 6, the ski-slope premiums are 27.5 and 22.6 percent for OLS and ML, respectively, and the implicit prices for ski-slope proximity are $606 and $498. With the exception of the two ski-access variables, modeling of spatial correlation does not have a large impact on the coefficient estimates or standard errors. This result repeats the outcome in several prior hedonic papers that estimate spatial models, including Benjamin, Jud, and Winkler (2001), Kim, Phipps, and Anselin (2003), Mollard, Rambonilaza, and Vollet (2007), Salvi (2008), and Mueller and Loomis (2008). As suggested by Bowen, Mikelbank, and Prestegaard (2001), correction for spatial correlation may not always be necessary in hedonic models, but spatial diagnostic tests and sensitivity analysis will help to ensure the robustness of empirical results. Their suggestion is borne out in the empirical results reported in the present paper.

Conclusions

This paper estimates hedonic price models for a sample of 610 vacation rental houses located in



Summer Rentals



Winter Rentals

Figure 1. Moran Scatterplots for OLS Residuals

Table 5. Spatial Correlation Regressions for Weekly Rentals

Variable	(1) Spatial lag: Summer	(2) Spatial error: Summer	(3) % effect: OLS, spatial error	(4) Spatial lag: Winter	(5) Spatial error: Winter	(6) % effect: OLS, spatial error
Constant	6.1127 (0.356)*	6.4166 (0.029)*	---	5.8189 (0.366)*	6.2917 (0.031)*	---
Occupants (no.)	0.0186 (0.004)*	0.0176 (0.004)*	1.88 (0.4), 1.86 (0.4)	0.0181 (0.004)*	0.0174 (0.004)*	1.85 (0.04), 1.74 (0.04)
Bedrooms (no.)	0.0634 (0.012)*	0.0670 (0.012)*	6.38 (1.2), 6.34 (1.2)	0.0998 (0.013)*	0.1021 (0.013)*	10.09 (1.3), 10.21 (1.3)
Bathrooms (no.)	0.0633 (0.009)*	0.0643 (0.009)*	6.28 (0.9), 6.33 (0.9)	0.0727 (0.009)*	0.0749 (0.009)*	7.18 (0.9), 7.49 (0.9)
King-size beds (%)	0.0005 (0.0003)	0.0005 (0.0003)	0.05 (0.03), 0.05 (0.03)	0.0007 (0.0004)	0.0007 (0.0004)	0.07 (0.04), 0.07 (0.04)
Lakefront	0.3608 (0.020)*	0.3658 (0.020)*	44.00 (2.8), 44.14 (2.8)	0.1933 (0.016)*	0.1940 (0.017)*	21.48 (2.0), 21.39 (2.1)
Split-lakefront	0.1148 (0.041)*	0.1143 (0.043)*	12.08 (4.7), 12.00 (4.8)	---	---	---
Private dock	0.1733 (0.026)*	0.1615 (0.028)*	18.54 (3.1), 17.49 (3.2)	---	---	---
Dock slip	0.0969 (0.017)*	0.0897 (0.018)*	10.07 (2.0), 9.37 (2.0)	---	---	---
Ski-slope access	---	---	---	0.2293 (0.028)*	0.2040 (0.035)*	27.46 (3.5), 22.55 (4.2)
Ski-road access	---	---	---	0.0577 (0.022)*	0.0374 (0.029)	6.79 (2.3), 3.77 (3.0)
Private pool	0.2917 (0.038)*	0.2920 (0.038)*	33.80 (5.2), 33.81 (5.0)	0.2819 (0.040)*	0.2788 (0.039)*	32.62 (5.4), 32.06 (5.2)
Community pool	0.1459 (0.027)*	0.1303 (0.033)*	15.30 (3.1), 13.85 (3.8)	0.0842 (0.028)*	0.0535 (0.035)*	8.05 (3.0), 5.44 (3.7)
Central AC	0.1336 (0.017)*	0.1375 (0.017)*	14.18 (2.0), 14.72 (1.9)	---	---	---
Jetted tub	0.0383 (0.013)*	0.0380 (0.013)*	3.98 (1.4), 3.86 (1.3)	0.0231 (0.015)	0.0228 (0.015)	2.44 (1.6), 2.30 (1.5)
Sauna	---	---	---	0.0594 (0.028)*	0.0527 (0.028)*	6.18 (3.0), 5.37 (2.9)
Extra fireplace	0.0515 (0.013)*	0.0478 (0.013)*	5.37 (1.4), 4.88 (1.4)	0.0580 (0.016)*	0.0565 (0.016)*	6.15 (1.8), 5.80 (1.7)
Pool table	0.0845 (0.015)*	0.0851 (0.015)*	8.93 (1.6), 8.87 (1.6)	0.0883 (0.017)*	0.0926 (0.017)*	9.38 (1.9), 9.68 (1.9)
Extra TVs	0.0197 (0.015)	0.0242 (0.015)	1.96 (1.5), 2.43 (1.5)	0.0365 (0.018)*	0.0457 (0.018)*	3.83 (1.9), 4.66 (1.9)
Internet access	0.0614 (0.018)*	0.0574 (0.018)*	6.42 (2.0), 5.89 (2.0)	0.0631 (0.016)*	0.0546 (0.016)*	6.49 (1.8), 5.60 (1.7)
Agency A houses	0.0961 (0.017)*	0.0978 (0.017)*	9.93 (1.9), 10.26 (1.9)	---	---	---
Rho value	0.0396 (0.047)	---	---	0.0633 (0.050)	---	---
Lambda value	---	0.3974 (0.105)*	---	---	0.4371 (0.125)*	
Log-likelihood	290.41	295.71	---	227.45	233.54	---
Avg. rent ($)	2684	2684	2684	2206	2206	2206

Notes: Spatial models estimated by maximum likelihood using Stata/IC 10. Dependent variables are the logs of 2008 weekly rental prices. Huber-White robust standard errors are in parentheses; asterisks indicate statistically significant coefficient at the 95 percent confidence level. OLS comparisons in columns 3 and 6 are with the spatial-error models (standard error in parentheses). All samples exclude the VRBO properties due to missing street addresses.

the vicinity of a lake and four-season ski-golf resort in rural western Maryland. Hedonic semi-log regression models are estimated for peak summer and peak winter weekly rentals for 2008. Selected results also are reported for late summer weekly rentals and winter weekend rentals. The regression estimates for rental prices are conditioned on explanatory variables for house size, house quality, and recreation features including lakefront proximity and ski-slope access. The estimates are used to obtain percentage effects and marginal implicit prices evaluated at the mean rent. The estimates provide evidence that access to recreation opportunities is reflected importantly in vacation rental prices. Lakefront locations command a rental premium of about \$1,100–1,200 per week, and the premium for ski-slope locations is \$500–600 per week. In addition to housing characteristics, implicit prices also are reported for split-lakefronts, ski-road access, dockage access, private swimming pools, and access to community swimming pools. The paper also reports maximum likelihood estimates that correct for spatial correlation. The preferred model is the spatial-error model. Although there is evidence of positive spatial correlation in the OLS residuals, estimation by maximum likelihood does not have a substantial effect on most coefficient magnitudes or standard error estimates. Given the nature of the data, omitted variables seem unlikely to confound the estimates of the model coefficients. On the other hand, a shortcoming of the present paper is the inability to carry out the Taylor-Smith (Taylor and Smith 2000) tests for the effect of market power in the hedonic price functions, which requires information on the vacancy rate for each property.

Bowen, Mikelbank, and Prestegaard (2001) argue that hedonic price models must conform to three criteria: parsimoniousness, plausibility, and informativeness. First, a model is parsimonious if it contains the minimum number of parameters required to identify key concepts. In the present study, information that is directly available to potential renters is used to model conditions of housing structure, quality, and location. The identification conditions in a rental market differ somewhat from residential housing, such as fixed contractual rental prices. Second, plausibility is satisfied if the concepts, variables, and empirical relationships are justified based on a larger body of knowledge. In the present study, plausibility is empirically justified due to the stability of the coefficients across different specifications for the same time period, and the lack of substantial variation when the model accounts for spatial correlation and dependence. Further, the marginal price for lakefront access is consistent with prior studies. Small differences exist across management agencies, which is a potential subject for further research. Third, the model and empirical results are informative with respect to the benefits derived from rural recreational features at Deep Creek Lake, including potential policy decisions regarding these and similar resources. One important feature of the resort site used in the present paper is the careful environmental oversight and land stewardship exercised by the state of Maryland. It is likely that this oversight is embodied generally in rental values at Deep Creek Lake.

Last, the economic costs and benefits of recreational subdivisions and second homes is an issue that can generate substantial controversy at the local level. Relatively few economic studies have examined this market or employed the rental market to generate recreation values. The present paper adds to the small literature on rural recreation values and the economic benefits of vacation houses. Additional research on benefits and costs for this issue is clearly desirable, and would be an aid to private developers, public officials, and consumers.

References

Anselin, L. 2003. "Spatial Externalities, Spatial Multipliers, and Spatial Econometrics." *International Regional Science Review* 26(2): 153–166.

Bell, J. 2007. "History of the Wisp Resort." Available at http://deepcreekhotproperties.blogspot.com/2007/08/history-of-wisp-resort.html (accessed November 16, 2009).

____. 2008. "About Deep Creek Lake." Available at http://deepcreekhotproperties.blogspot.com/2008/05/about-deep-creek-lake-jon-bell-railey.html (accessed November 16, 2009).

Benjamin, J.D., G.D. Jud, and D.T. Winkler. 2001. "The Value of Smoking Prohibitions in Vacation Rental Properties." *Journal of Real Estate Finance and Economics* 22(1): 117–128.

Bockstael, N.E., K.E. McConnell, and I.E. Strand. 1991. "Recreation." In J.B. Braden and C.D. Kolstad, eds., *Measuring the Demand for Environmental Quality*. Amsterdam: North-Holland.

Bond, M.T., V.L. Seiler, and M.J. Seiler. 2002. "Residential Real Estate Prices: A Room with a View." *Journal of Real Estate Research* 23(1/2): 129–137.

Bowen, W.M., B.A. Mikelbank, and D.M. Prestegaard. 2001. "Theoretical and Empirical Considerations Regarding Space in Hedonic Housing Price Model Applications." *Growth and Change* 32(4): 466–490.

Butsic, V., E. Hanak, and R.G. Valletta. 2008. "Climate Change and Housing Prices: Hedonic Estimates for North American Ski Resorts." Working Paper No. 2008-12, Federal Reserve Bank of San Francisco, San Francisco, CA.

Can, A. 1990. "The Measurement of Neighborhood Dynamics in Urban House Prices." *Economic Geography* 66(3): 254–272.

Day, B.H. 2001. *The Theory of Hedonic Markets: Obtaining Welfare Measures of Changes in Environmental Quality Using Hedonic Market Data*. Economics for the Environment Consultancy, London, UK.

Deep Creek Times. 2009. Map of Deep Creek Lake. Available at http://www.deepcreektimes.com/images/dclmap1.jpg (accessed November 16, 2009).

Deller, S., and V. Lledo. 2007. "Amenities and Rural Appalachia Economic Growth." *Agricultural and Resource Economics Review* 36(1): 107–132.

Deller, S.C., T.-H. Tsai, D.W. Marcouiller, and D.B.K. English. 2001. "The Role of Amenities and Quality of Life in Rural Economic Growth." *American Journal of Agricultural Economics* 83(2): 352–365.

Dissart, J.C., and D.W. Marcouiller. 2005. "Impact of Outdoor Recreation Facilities on Remote Rural Income Growth." In G.P. Green, S.C. Deller, and D.W. Marcouiller, eds., *Amenities and Rural Development: Theory, Methods and Public Policy*. Cheltenham, UK: Edward Elgar.

Dubin, R.A. 1988. "Estimation of Regression Coefficients in the Presence of Spatially Autocorrelated Error Terms." *Review of Economics and Statistics* 70(3): 168–173.

____. 1998. "Spatial Autocorrelation: A Primer." *Journal of Housing Economics* 7(4): 304–327.

Freeman, A.M. 2003. *The Measurement of Environmental and Resource Values: Theory and Methods* (2nd ed.). Washington, D.C.: Resources for the Future.

Geoghegan, J., L.A. Wainger, and N.E. Bockstael. 1997. "Spatial Landscape Indices in a Hedonic Framework: An Ecological Economics Analysis using GIS." *Ecological Economics* 23(3): 251–264.

Gibbs, J.P., J.M. Halstead, K.J. Boyle, and J.-C. Huang. 2002. "An Hedonic Analysis of the Effects of Lake Water Clarity on New Hampshire Lakefront Properties." *Agricultural and Resource Economics Review* 31(1): 39–46.

Hanley, N., and E.B. Barbier. 2009. *Pricing Nature: Cost-Benefit Analysis and Environmental Policy*. Cheltenham, UK: Edward Elgar.

Hite, D. 1998. "Information and Bargaining in Markets for Environmental Quality." *Land Economics* 74(3): 303–316.

Johnson, K.M., and C.L. Beale. 2002. "Nonmetro Recreation Counties: Their Identification and Rapid Growth." *Rural America* 17(4): 12–19.

Johnston, R.J., J.J. Opaluch, T.A. Grigalunas, and M.J. Mazzotta. 2001. "Estimating Amenity Benefits of Coastal Farmland." *Growth and Change* 32(2): 305–325.

Kennedy, P.E. 1981. "Estimation with Correctly Interpreted Dummy Variables in Semilogarithmic Equations." *American Economic Review* 71(4): 801–802.

____. 2003. *A Guide to Econometrics* (5th ed.). Cambridge, MA: MIT Press.

Kim, C.W., T.T. Phipps, and L. Anselin. 2003. "Measuring the Benefits of Air Quality Improvement: A Spatial Hedonic Approach." *Journal of Environmental Economics and Management* 45(1): 24–39.

Knight, J.R. 2008. "Hedonic Modeling of the Home Selling Process." In A. Baranzini, J. Ramirez, C. Schaerer, and P. Thalmann, eds., *Hedonic Methods in Housing Markets: Pricing Environmental Amenities and Segregation*. New York: Springer.

LeSage, J., and R.K. Pace. 2009. *Introduction to Spatial Econometrics*. Boca Raton, FL: CRC Press.

Maryland Department of Natural Resources. 2001. "Deep Creek Lake Recreation and Land Use Plan." Available at http://www.dnr.state.md.us/publiclands/western/deepcreek lake.html (accessed November 16, 2009).

MDNR [*see* Maryland Department of Natural Resources].

Mollard, A., T. Rambonilaza, and D. Vollet. 2007. "Environmental Amenities and Territorial Anchorage in the Recreational-Housing Rental Market: A Hedonic Approach with French Data." *Land Use Policy* 24(2): 484–493.

Mueller, J., and J.B. Loomis. 2008. "Spatial Dependence in Hedonic Property Models: Do Different Corrections for Spatial Dependence Result in Economically Significant Differences in Estimated Implicit Prices?" *Journal of Agricultural and Resource Economics* 33(2): 212–231.

Palmquist, R.B. 1992. "Valuing Localized Externalities." *Journal of Urban Economics* 31(1): 59–68.

Pope, J.C. 2008. "Do Seller Disclosures Affect Property Values? Buyer Information and the Hedonic Model." *Land Economics* 84(4): 551–572.

Reeder, R.J., and D.M. Brown. 2005. "Recreation, Tourism, and Rural Well-Being." Economic Research Report No. 7, Economic Research Service, U.S. Department of Agriculture, Washington, D.C.

Rush, R., and T.H. Bruggink. 2000. "The Value of Ocean Proximity on Barrier Island Houses." *Appraisal Journal* 68(2): 142–150.

Salvi, M. 2008. "Spatial Estimation of the Impact of Airport Noise on Residential Housing Prices." *Swiss Journal of Economics and Statistics* 144(4): 577–606.

Smith, V.K., and R.B. Palmquist. 1994. "Temporal Substitution and the Recreational Value of Coastal Amenities." *Review of Economics and Statistics* 76(1): 119–126.

Soguel, N., M.-J. Martin, and A. Tangerini. 2008. "The Impact of Housing Market Segmentation between Tourists and Residents on the Hedonic Price for Landscape Quality." *Swiss Journal of Economics and Statistics* 144(4): 655–678.

Taylor, L.O., and V.K. Smith. 2000. "Environmental Amenities as a Source of Market Power." *Land Economics* 76(4): 550–568.

Timothy, D.J. 2004. "Recreational Second Homes in the United States: Development Issues and Contemporary Patterns." In C.M. Hall and D.K. Muller, eds., *Tourism, Mobility and Second Homes: Between Elite Landscape and Common Ground*. Clevedon, UK: Channel View.

U.S. Bureau of the Census. 2009. "Total Housing Inventory for the United States." *Statistical Abstract of the United States* (Table 940). Washington, D.C.: U.S. Government Printing Office. Available at http://www.census.gov (accessed November 16, 2009).

van Garderen, K.J., and C. Shah. 2002. "Exact Interpretation of Dummy Variables in Semilogarithmic Equations." *Econometrics Journal* 5(1): 149–159.

Wheaton, W.C. 2005. "Resort Real Estate: Does Supply Prevent Appreciation?" *Journal of Real Estate Research* 27(1): 1–16.

Wilman, E.A. 1981. "Hedonic Prices and Beach Recreational Values." In V.K. Smith, ed., *Advances in Applied Microeconomics* (Vol. 1). Greenwich, CT: JAI Press.

____. 1984. *External Costs of Coastal Beach Pollution: An Hedonic Approach*. Washington, D.C.: Resources for the Future.

Zerbe, R.O., and D.W. Dively. 1994. *Benefit-Cost Analysis: In Theory and Practice*. New York: HarperCollins.

Data Appendix

Data Sources

Data were obtained from rental catalogs and associated websites of three management agencies: Coldwell Banker Deep Creek Realty's "2008 Vacation Rental Guide" (www.deepcreekrealty.com), Long & Foster Real Estate's "2008 Rental Guide" (www.deepcreekresort.com), and Railey Mountain Lake Vacations' "2008 Rental Vacation Guide" (www.rentals.deepcreek.com). All sites were accessed for data in December 2008. Rent-by-owner data for fifty houses were obtained from "VRBO Vacation Rentals" (http://www.vrbo.com). Due to missing data, two smaller management agencies with about 25 properties each were omitted from the study.

Sample Restrictions

Rentals were restricted to detached houses that accommodate at least 6 persons. No condominiums or townhouses were included, but several duplexes were included. One super-luxury house was excluded from all samples.

Dependent Variables

Weekly and weekend rental prices were collected for the peak winter, late summer, and peak summer (weekly only) rental periods. Rental prices include linen fees, but exclude taxes and optional charges (e.g., dock slip rentals). For Railey Vacations, rental prices for 15 of its "classic houses" were adjusted upward for a bed linen and bath towel fee ($17 per bedroom multiplied by the number of bedrooms). Some of the VRBO properties also reflect separate linen fees reported on the website.

Independent Variables

- *Occupants:* maximum number of persons allowed
- *Bedrooms:* number of bedrooms
- *Bathrooms:* number of bathrooms, including half-baths
- *King-size beds:* percentage of bedrooms with a king-size bed
- *Lakefront* dummy (see Table 2)
- *Split-lakefront* dummy (see Table 2)
- *Lake-access* dummy (see Table 2)
- *Lake-area* dummy (see Table 2)
- *Ski slope-access* dummy (see Table 2)
- *Ski-road access* dummy (see Table 2)
- *Private and public golf* dummies (see Table 2)
- *Private dock* dummy: house has a private dock
- *Dock slip* dummy: house has free access to a community dock slip
- *Private pool* dummy: house has a private swimming pool (30 of 32 are indoor pools)
- *Community pool* dummy: house is located in an area with access to an indoor community pool
- *Central AC* dummy: house has central air conditioning
- *Sauna* dummy: house has a sauna
- *Jetted tub* dummy: house has one or more jetted tubs or jacuzzi
- *Extra fireplace* dummy: house has more than one fireplace or wood stove
- *Pool table* dummy: house has a pool table and game room
- *Extra TVs* dummy: house has four or more television sets
- *Internet access* dummy: house has access to Internet (can be wireless, high-speed, or other)
- *Agency* dummies (see Table 2)

Several other quality variables (extra grills, extra hot tubs, extra VCRs, extra DVDs, two kitchens, etc.) were insignificant in preliminary regressions and on grounds of parsimony have been deleted from the final models. Lake access and lake-area locations are incorporated into the constant terms.

Spatial Weights

Latitude and longitude values were obtained using the address of the house and the website for iTouchMap.com. Latitude and longitude were not available for VRBO houses due to missing addresses. For the spatial regressions, standard formulas were used to translate latitude-longitude coordinates to Cartesian coordinates in meters. Four possible distance bands were examined for spatial weights, and the final weights are based on 400-meter bands (spatial estimates with 600-meter bands were very similar). Bands greater than 600 meters yielded similar results, but contained fewer significant variables. Distance bands smaller than 400 meters were not possible due to missing neighbor problems.

Table A1. Descriptive Statistics

Variable	Mean (s.d.)	Median	Min.	Max.	Non-zero	Smpl N	VIF
Summer week ($)	2637 (1484)	2155	595	8852	610	610	---
Winter week ($)	2178 (1297)	1828	572	8548	577	577	---
Late summer ($)	2420 (1411)	1977	555	8548	610	610	---
Occupants (max. no.)	12.2 (4.1)	12	6	28	610	610	5.95
Bedrooms (no.)	4.5 (1.4)	4.0	2.0	9.0	610	610	6.33
Bathrooms (no.)	3.7 (1.5)	3.5	1.0	9.5	610	610	4.98
King-size beds (%)	26.8 (25.1)	25.0	0.0	100.0	415	610	1.48
Lakefront	0.47 (0.50)	0.0	0.0	1.0	286	610	2.62
Split-lakefront	0.04 (0.19)	0.0	0.0	1.0	24	610	1.32
Ski-slope access	0.11 (0.31)	0.0	0.0	1.0	64	577	1.16
Ski-road access	0.06 (0.23)	0.0	0.0	1.0	33	577	1.05
Private dock	0.33 (0.47)	0.0	0.0	1.0	201	610	3.56
Dock slip	0.38 (0.48)	0.0	0.0	1.0	229	610	1.93
Private pool	0.05 (0.22)	0.0	0.0	1.0	32	610	1.31
Public pool	0.04 (0.21)	0.0	0.0	1.0	27	610	1.07
Central AC	0.69 (0.46)	1.0	0.0	1.0	419	610	1.66
Sauna	0.06 (0.24)	0.0	0.0	1.0	35	577	1.26
Jetted tub	0.48 (0.50)	0.0	0.0	1.0	292	610	1.38
Extra fireplace (>1)	0.47 (0.50)	0.0	0.0	1.0	285	610	1.46
Pool table (>0)	0.55 (0.50)	1.0	0.0	1.0	336	610	1.59
Extra TVs (>4)	0.50 (0.50)	1.0	0.0	1.0	306	610	1.72
Internet access	0.63 (0.48)	1.0	0.0	1.0	382	610	1.19

Notes: "Non-zero" is a count of the number of non-zero values for each variable. "Smpl N" is the maximum sample size for each variable in the summer sample. "VIF" is the variance inflation factor computed from regressing each explanatory variable on a set of fifteen other independent variables; mean VIF is 2.26. As a rule of thumb, VIF values that exceed 8–10 are indicative of harmful multicollinearity (Kennedy 2003).