A HEDONIC PRICING ANAYLSIS OF LAKE TAHOE REAL ESTATE DYMANICS

A THESIS

Presented to

The Faculty of the Department of Economics and Business

The Colorado College

In Partial Fulfilment of the Requirements for the Degree

Bachelor of Arts

By:

Kaelin Woodruff

May 2024

A HEDONIC PRICING ANAYLSIS OF LAKE TAHOE REAL ESTATE DYMANICS

Kaelin Woodruff

May 2024

Business, Economics, and Society

Abstract

A hedonic pricing model is used estimated to analyze the impact of economic factors and climate variability on real estate prices in the Lake Tahoe region. Using housing data from 135 U.S. Census tracts from 2018 – 2022, along with snowfall data, this study finds that increases in median income, population density and the build year are statistically significant.

KEYWORDS: (Hedonic Pricing Model, Housing Data, Lake Tahoe)

JEL CODES: (R21, Q54, R31, Q51)

ON MY HONOR, I HAVE NEITHER GIVEN NOR RECEIVED UNAUTHORIZED AID ON THIS THESIS

Signature

Table of Contents

List of Tables

List of Figures

Acknowledgments

I would like to extend my deepest gratitude to my advisor, Professor Aju Fenn, whose unwavering guidance, support, and encouragement have been invaluable throughout this entire process. You have been instrumental in preparing me for the challenges beyond college, guiding me through the complexities of this research with invaluable insight and support. A special thank you goes to Matt Cooney, the GIS specialist, who played a crucial role in consolidating the data necessary for this study. Matt, your expertise in Geographic Information Systems and your willingness to assist in creating the maps for this thesis have greatly enriched my research. I would also like to express my heartfelt appreciation to my parents, who have given me the opportunity to pursue my studies at Colorado College. Thank you for believing in me and providing me with the foundation to succeed. Finally, a big thank you goes out to Van Butsic, Ellen Hanak, and Robert G. Valletta, the authors of "Climate Change and Housing Prices: Hedonic Estimates for Ski Resorts in Western North America." Your work has been instrumental in shaping my understanding of the intersections between climate change, housing markets, and tourism. I sincerely appreciate the provision of your data, which served as the foundation for my own, and I am grateful for the insights your study has provided. Thank you all for your invaluable contributions to my thesis.

1. Introduction

The trend in home prices across the U.S. has seen a significant increase over the past several decades, driven by various economic, social, and demographic factors (National Association of Realtors 2021). A combination of high demand, due to changing lifestyle preferences and a limited supply, has pushed home prices to new heights in many parts of the country. Hedonic pricing models have been widely used by economists and real estate professionals to explain the variations in housing prices across different markets. These models aim to assess how different factors—such as location, size, features, environmental aspects, proximity to amenities, and the overall housing market—contribute to a home's price. Although much research has focused on the rise in housing prices in large metropolitan areas, this paper will shift its attention to pricing trends in the non- metropolitan area of Lake Tahoe. I will specify and estimate a hedonic pricing model introduced by Butsic, Hanak, and Valletta (2011) for the Lake Tahoe area using census data on average annual home prices, home characteristics, and elevation in each of the 135 census tracts from 2018 to 2022.

FIGURE 1

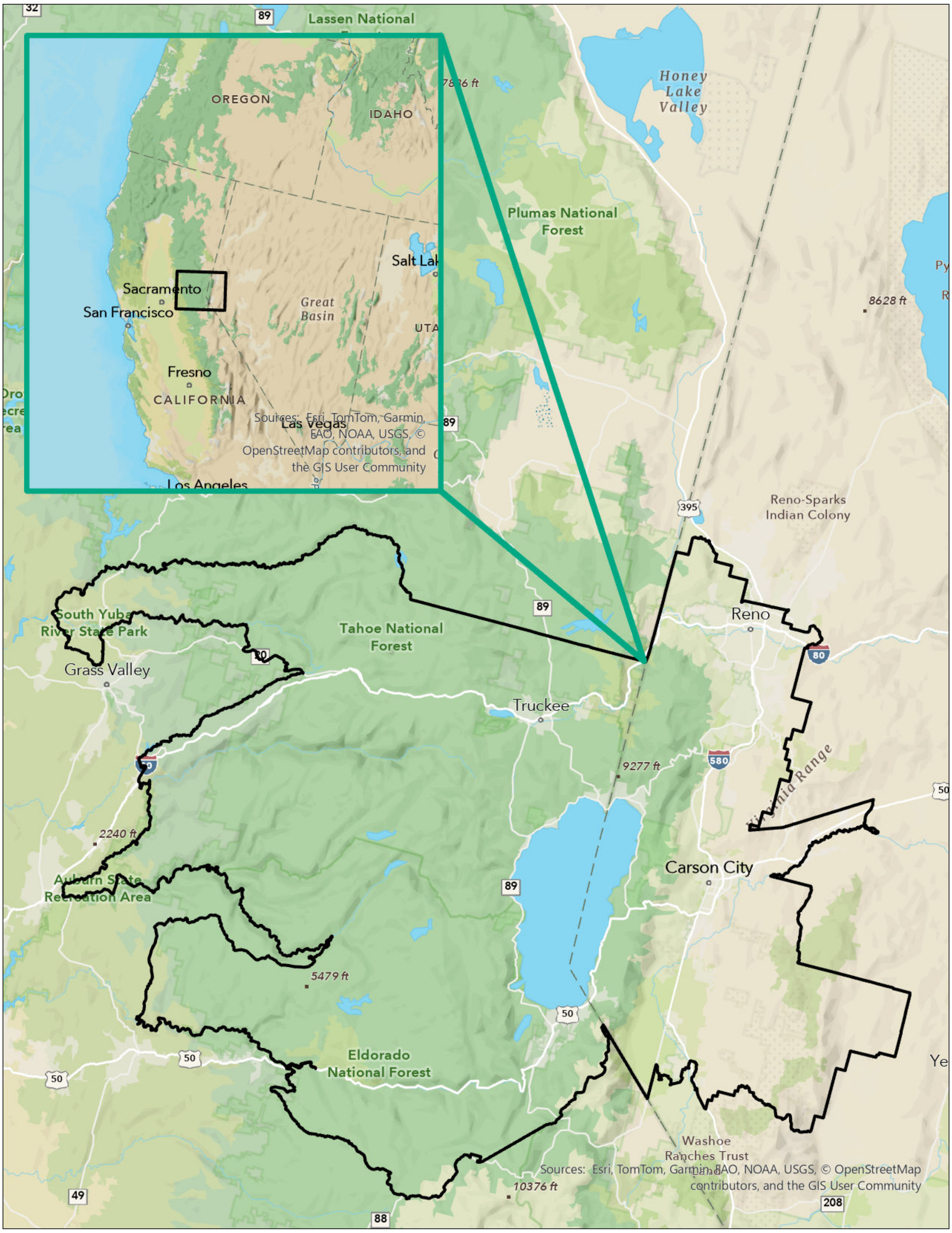

Figure 1 presents a reference map highlighting the specific areas of California and Nevada that are the focus of this study. Therefore, this detailed reference map not only pinpoints the specific area of interest but also offers important geographical information that enhances a thorough understanding of the study's dynamics.

2. Literature Review

Hedonic Pricing Model

The literature on hedonic models originates from Sherwin Rosen's (1974) foundational work, which formalized the concept of goods as bundles of characteristics, with prices determined by the sum of these attributes. Since then, hedonic pricing models have been widely applied, especially in real estate markets to analyze property values based on factors such as location, environmental quality, and neighborhood amenities (Harrison & Rubinfeld 1978; Palmquist 1984). Applications extend to urban economics, examining the effect of public goods and infrastructure (Gyourko & Tracy 1991) and tourism markets where natural amenities drive real estate demand (Taylor & Smith, 2000). The methodology has evolved with advances in econometrics, such as spatial dependency and unobserved product characteristics (Bajari & Benkard 2005). While Rosen is considered the foundational work, subsequent research has expanded the model's application, refined its methodology, and adapted it to various contexts, including policy analysis, non-market valuation, and quality adjustments in price indices.

The hedonic price model is a widely used economic tool for estimating the value of individual attributes that contribute to the overall price of a good, particularly in the housing market. Derived from the works of Lancaster (1966) and Rosen (1974), the model posits that products, including homes, are viewed as bundles of characteristics, and their prices reflect the combined implicit values of these attributes. In the housing market, these characteristics can include locational, structural, and neighborhood factors, such as proximity to amenities, the number of rooms, or the quality of the view (Chin & Chau 2003). By employing regression analysis, the hedonic model allows researchers to break down property prices into the marginal values of these various attributes, offering a more nuanced understanding of what drives price differences between properties. Despite its limitations, the model remains a fundamental tool for understanding housing market dynamics and consumer preferences (Chin & Chau 2003).

The role of supply and demand in the hedonic pricing model are essential to understanding housing market dynamics. The model, as developed by Rosen (1974), incorporates both demand—buyers' willingness to pay for certain attributes—and supply—the availability of homes with those attributes. On the demand side, consumers' willingness to pay for housing attributes, such as proximity to schools or larger floor areas, is influenced by their income, preferences, and utility levels (Rosen 1974). As income rises, for example, consumers may be willing to pay more for desirable features in a property. On the supply side, the model assumes that housing is elastically supplied, meaning that an increase in demand should lead to an increase in the availability of homes with desirable characteristics. However, in practice, housing supply can be less flexible due to factors like land constraints and regulatory restrictions (Bartik 1987). The model also assumes that housing markets reach equilibrium, where supply matches demand, and the implicit prices of attributes reflect this balance. Yet, real-world markets often fail to achieve perfect equilibrium due to imperfections such as information asymmetry and supply-side constraints (Chin & Chau 2003). While the hedonic price model helps estimate housing prices in theory, the interaction between supply and demand can be complex, and constraints on the housing supply can lead to higher prices when demand rises (Bartik 1987; Chin & Chau 2003).

Understanding the dynamics of supply and demand in the housing market requires a closer examination of the specific attributes that drive these forces. A standard supply and demand model is insufficient for real estate because it fails to account for the unique characteristics of individual properties. Unlike the supply and demand approach, the hedonic pricing model captures the intrinsic attributes that significantly influence property values (Chin & Chau 2003). The hedonic price model breaks down housing prices into locational, structural, and neighborhood attributes, each of which significantly influences buyer preferences and market trends. Locational attributes, such as proximity to the Central Business District (CBD), transport access, scenic views, and environmental quality, are crucial in shaping demand, as buyers often prioritize convenience and environmental desirability (Follain & Jimenez 1985; Benson et al. 1998; Espey & Lopez 2000). Structural attributes, including the size of the property, number of rooms, age, and the presence of amenities like garages or swimming pools, influence the functional appeal of a house, making larger and better-equipped homes more attractive (Carroll et al., 1996; Garrod & Willis, 1992). Neighborhood attributes, such as income levels, school quality, crime rates, and proximity to shopping centers or parks, significantly affect the desirability of the area, impacting housing demand accordingly (Clauretie & Neill 2000; Thaler 1978; Tyrvainen 1997). The significance of housing attributes in the hedonic price model lies in their ability to determine utility for buyers, which directly shapes market demand and pricing (Rosen 1974). Locational attributes act as proxies for opportunity cost savings by reducing commuting time and expenses, thereby increasing property value. Similarly, attributes like scenic views and environmental quality enhance the non-monetary utility of a home, driving higher willingness to pay for properties with superior aesthetic or environmental features (Benson et al. 1998). Structural attributes reflect a property's capital and functional value. Larger homes with more rooms and modern amenities offer greater marginal utility by providing more living space and comfort, translating into higher consumer surplus and elevated prices (Carroll et al. 1996). Neighborhood attributes, such as socioeconomic status, school quality, and crime rates, serve as markers of social capital and access to public goods, which strongly influence housing demand (Clauretie & Neill 2000; Thaler 1978). These factors impact perceived safety and quality of life while also affecting surrounding property values. Because these desirable attributes are often scarce due to geographic or regulatory constraints, they create supply-side inelasticity, leading to disproportionate price increases when demand rises (Chin & Chau 2003). Collectively, these attributes drive price differentiation and market segmentation, shaping the supply-demand balance in housing markets. The model highlights the interplay of these attributes, allowing for detailed analysis of how supply and demand dynamics shape housing prices in different markets (Chin & Chau 2003).

Similarly to Chin & Chau (2003), Ayse Can (1992) builds on Rosen's (1974) framework to extend the application of hedonic price models to urban housing markets by analyzing the relationship between housing prices and various structural attributes (e.g., number of rooms, lot size) and locational attributes (e.g., neighborhood quality). Rooted in Rosen's framework, which conceptualizes housing as a bundle of characteristics, Can's model emphasizes how market prices reflect an equilibrium between buyers' demand and sellers' supply. The focus is on capturing the marginal implicit price of each attribute. In addition, the model incorporates spatial effects, including:

(1) Neighborhood effects: the impact of shared neighborhood characteristics, such as access to public amenities or socio-economic factors.
(2) Adjacency effects: the spillover impact of nearby houses' prices on a specific house's value, representing spatial interdependence in pricing.

Both spatial effects have an impact on the supply and demand variables mentioned earlier in the paper. In the Can (1992) article, neighborhood effects and adjacency effects play critical roles in shaping housing prices through their influence on both supply and demand in urban housing markets.

Neighborhood effects change demand as buyers are willing to pay premiums for homes in neighborhoods with superior amenities (schools, parks) and higher socio-economic standing. This increases demand in these areas, elevating housing prices. On the supply side, sellers in these neighborhoods adjust by setting higher prices, as demand for housing in such areas outstrips supply. Developers also focus new housing in desirable neighborhoods, creating a localized price premium. In Can's framework, neighborhood effects are modeled as locational externalities that directly impact the overall pricing function by causing variations in the marginal prices of structural attributes. Houses in higher-quality neighborhoods see an increase in the implicit price of attributes compared to those in lower-quality areas. Can (1992) introduces an alternative framework to address spatial heterogeneity in hedonic price models by applying Casetti's expansion method (1972; 1986). This approach allows the parameters of the hedonic price function (HPF) to vary across the urban landscape based on neighborhood effects. The function can be expressed as:

$$P = f(S, \beta) + \varepsilon, \text{ where } \beta = g(N) \qquad (1)$$

In Can's (1992) model, marginal attribute prices vary continuously across space rather than in discrete segments, replacing switching regressions with a more flexible, spatially dynamic approach. This allows for a detailed analysis of how neighborhood characteristics impact pricing and tests for structural instability. In Can's framework, neighborhood effects act as local externalities, directly influencing the implicit prices of structural attributes; homes in high-quality neighborhoods command higher prices for similar features compared to those in lower-quality areas. Can further incorporates spatial heterogeneity, using Casetti's expansion method to allow the parameters of the hedonic price function to vary across different neighborhoods, providing a more dynamic and localized understanding of housing markets.

Adjacency effects influence demand and supply in slightly different ways. On the demand side, buyers use the prices of surrounding properties as indicators of value. When nearby homes are priced higher, this signals a higher demand for the area, encouraging buyers to offer more. On the supply side sellers increase prices in response to rising prices in neighboring homes, reducing the relative supply of affordable housing in that specific location. This approach to housing price determination requires explicitly accounting for the interdependence between the prices of neighboring homes through an autoregressive specification. Introduced by Can (1990) as an alternative to traditional econometric models, this method incorporates spatial effects, capturing how the price of one house depends on the prices of surrounding properties. The function can be represented as:

$$P = f(WP, S, N, \rho, \beta, \gamma) + \varepsilon \qquad (2)$$

where P is a vector of observed market expenditures of housing (market rent or house value); S and N are vectors of structural characteristics and neighborhood characteristics; β and γ are the corresponding parameter vectors; W is the generalized weight matrix; WP is the spatially lagged dependent variable (weighted sum of the values of the dependent variable at other locations); ρ is its coefficient; and ε is the vector of random error terms (Can 1992). Compared to Chin and Chau's (2003) model, which focuses on static locational attributes like proximity to amenities and their broad impact on supply and demand, Can's (1992) model adds complexity by addressing locational externalities between homes. While Chin and Chau (2003) emphasize market equilibrium, they do not account for how neighboring property prices influence each other. Can's (1992) use of local spillover effects introduces a dynamic pricing mechanism where local interactions create ripple effects, making her approach more adaptable to real-world markets where adjacency and neighborhood effects significantly impact price determination.

Both the Chin and Chau (2003) and Can (1992) articles lay the foundation for understanding the role of housing characteristics and spatial dynamics in determining property prices. Chin and Chau focus on specific attributes that influence housing prices, while Can (1992) incorporates spatial heterogeneity, emphasizing local variations in housing markets. Butsic, Hanak, and Valletta (2011) expand their models to examine how climate factors, particularly snowfall intensity, influence housing prices near ski resorts, thus adding a climate dimension to the spatial and attribute-based analysis. The goal is to use this framework to understand the economic impact of climate change on ski resort areas. The model is shown below:

$$\ln(price_{it}) = \beta_0 + \beta_1 S_{it} + \beta_2 Q_{it} + \beta_3 N_{it} + \beta_4 T_{it} + \varepsilon_{it} \qquad (3)$$

The equation models how housing prices (in logarithmic form) depend on four key factors: structural attributes (S), environmental factors (Q), locational characteristics (N), and time of sale (T). The error term (ε_{it}) accounts for random effects, clustered by year. This model, similar to Can (1992), applies hedonic pricing but adds climatic variables such as snowfall intensity to assess their impact on real estate near ski resorts. By estimating the parameters (β's) for each region separately, Butsic, Hanak, and Valletta (2011) emphasize spatial and temporal variation across different market conditions, which is consistent with the spatial heterogeneity and equilibrium pricing framework found in Can's (1992) model.

Application to Mountain Towns

While previous research on hedonic models has predominantly focused on larger metropolitan areas, the lens will now shift to mountain towns, specifically examining how these models capture the unique value of these regions. In ski towns, key attributes like proximity to ski resorts and outdoor activities consistently drive-up home prices, reflecting the high value placed on these amenities by both tourists and second-home buyers (Berger et al. 1988; Meltzer & Cheung 2014). Ski resorts act as economic focal points, attracting seasonal visitors and investors seeking rental income opportunities, which leads to increased demand for local properties.

Recent studies highlight the role of short-term rental platforms like Airbnb in inflating housing prices. By creating additional demand while constraining supply for permanent residents, these platforms have raised property values, often pricing out local buyers and disrupting the economic balance of these communities (Blanco & Cheer 2018). Furthermore, environmental amenities significantly enhance property values, underscoring the economic importance of preserving these natural assets (Taylor 2003). However, climate change poses a growing threat to these areas. Lower-elevation ski towns, in particular, are vulnerable to reduced snowfall, which could decrease both tourism and housing demand, potentially lowering property values over time (Pace & Gilley 1997; Butsic, Hanak, & Valletta 2011).

Since the 1990s, rising real estate prices have led to displacement of local workforces in ski towns, a trend that has only intensified since the COVID-19 pandemic. For example, average single-family home prices in Steamboat, CO, reached $1.73 million in 2023, an 85% increase from the pre-pandemic average (Blevins 2023). Bozeman, MT, saw a 56% increase in residential median home prices from 2020 to 2024, while Jackson Hole, WY, and Sun Valley, ID, saw 36% and 76%

increases, respectively (Redfin 2024). However, wage growth in these regions has not kept pace with the rapid increase in housing costs, with incomes rising by only about 8% in Colorado, Montana, and Utah, and by lower rates in Wyoming, Idaho, and Nevada (Simard 2023).

Additionally, the increase in second-home ownership has significantly impacted housing affordability for locals. For instance, over 66% of homes in Breckenridge, CO, and over 79% in Winter Park, CO, are vacant or seasonally occupied (Workforce Housing Report 2023). This trend is exacerbated by recent price surges, which have intensified the shortage of affordable housing. Without substantial income growth, locals are often unable to afford homes in these regions, necessitating alternative solutions to ensure that local workers can live where they work.

The Lake Tahoe Housing Market

This paper provides a unique contribution by focusing specifically on the determinants of home prices within the Lake Tahoe region. Unlike previous studies, it delves into how home prices are affected by variables such as characteristics of a home (number of rooms), median income, and elevation.

Several hedonic features contribute to rising housing prices in Lake Tahoe, with property characteristics like house size, number of bedrooms, and overall square footage being key factors. Larger homes with more rooms are particularly desirable in this market (Lake Tahoe Property Report 2022). For instance, homes with four or more bedrooms in Lake Tahoe tend to have significantly higher values, as they accommodate the demand for larger rental properties that can house multiple families or groups (Lake Tahoe Property Report 2022). In addition to size, amenities like modern kitchens, multiple bathrooms, and dedicated outdoor spaces also contribute to higher property values. Homes featuring luxury amenities, such as hot tubs, large decks with lake or mountain views, and updated interiors, command premiums compared to those without such features (Meltzer & Cheung 2014). The presence of garages and additional storage space also adds value, as buyers prioritize the convenience of storing outdoor gear like skis, boats, and hiking equipment. Furthermore, short-term rental platforms like Airbnb have increased the value of properties with these features, as travelers often seek homes that offer more space and amenities compared to traditional hotel accommodations, driving up demand for larger, well-equipped properties in proximity to recreational activities (Blanco & Cheer 2018).

Income trends in the Tahoe Basin reveal an increase in median household income, though not at a pace that aligns with skyrocketing housing prices. From 2019 to 2021, the median income in Washoe County's portion of Lake Tahoe rose by 29%, a figure dwarfed by the 65% increase in average home prices over the same period (Tahoe Demographics 2021; Dundas 2023). This income disparity highlights the affordability challenges faced by residents, as rising property values continue to outstrip the modest increases in local wages. As a result, local workers are increasingly priced out of the housing market, while wealthier buyers, often from urban areas, invest in second homes, further inflating property values (Simard 2023).

Snowfall is another critical factor influencing property values in Lake Tahoe, as it directly affects the ski season length and, consequently, housing demand. A study by Hamilton et al. (2007) found that properties in ski towns with more reliable snowfall experienced higher appreciation rates, as the extended season attracted more tourists and second-home buyers. In Lake Tahoe, snowfall has historically been a key draw for winter tourism, with properties near ski resorts experiencing consistent price appreciation due to their proximity to popular skiing destinations.

The application of hedonic pricing models to the Lake Tahoe real estate market shows the substantial influence of recreational and environmental attributes on property values. The model proves that the Lake Tahoe housing market is not only shaped by the physical features of properties but also by broader environmental factors that significantly affect demand and pricing dynamics.

3. Theory and Methodology

The model used in this paper will be an adaptation of the framework developed by Butsic, Hanak, and Valletta (2011). In keeping with Butsic, Hanak, and Valletta (2011), I model the determinants of housing prices ($Price_i$) using a hedonic price function (HPF). The relationship is expressed mathematically as:

$$\ln(price_{it}) = \beta_0 + \beta_1 I_{it} + \beta_2 YB_{it} + \beta_3 R_{it} + \beta_5 PD_{it} + \beta_6 E_{it} + \varepsilon_{it} \tag{4}$$

Where:

$(price_{it})$ = sale price of property *i* at time *t*

I_{it} = Median income

YB_{it} = Median year built of homes

R_{it} = Average number of rooms

PD_{it} = Population density

E_{it} = Elevation or SI_{it} = Snowfall intensity

ε_{it} = Error term accounting for year-specific effects and other unobserved factors

3.1. Methodology

I use annual average data on home prices from 135 census tracts for each year from 2018– 2022. The dataset consists of 5 separate subsets of data by year for each of the years. I adopt this approach because the census tracts were increased and renumbered in 2022, making a panel data analysis infeasible. The renumbering and addition of new census tracts caused the dataset to become unbalanced, and ultimately resulting in 609 total observations. In each year the data consists of the dependent variable's average housing prices per tract. The independent variables also stated per tract are the average number of rooms per house, population density per square mile, average year of build, and average elevation. All nominal variables such as average home price and median income were converted into constant 1882-84 Dollars by deflating them by the Consumer Price Index for all urban consumers (Bureau of Labor Statistics n.d.).

Home Characteristics

The data on home characteristics and prices were obtained from the American Community Survey (ACS), which draws from U.S. Census data to provide detailed insights into various housing attributes. Census tracts were selected based on their geographic proximity, specifically within a 35-mile radius of the central point of each ski resort. To further refine the selection, these tracts also needed to be within 35 miles of a weather station located at an elevation above 4,000 feet. If a Census tract's center fell within the 35-mile radius, it was included in the analysis. Applying these criteria yielded approximately 135 Census tracts per year, totaling 609 observations for the period from 2018 to 2022. These selected tracts encompass regions in both Lake Tahoe, CA, and Lake Tahoe, NV, extending beyond the core resort towns to capture broader community impacts.

FIGURE 2

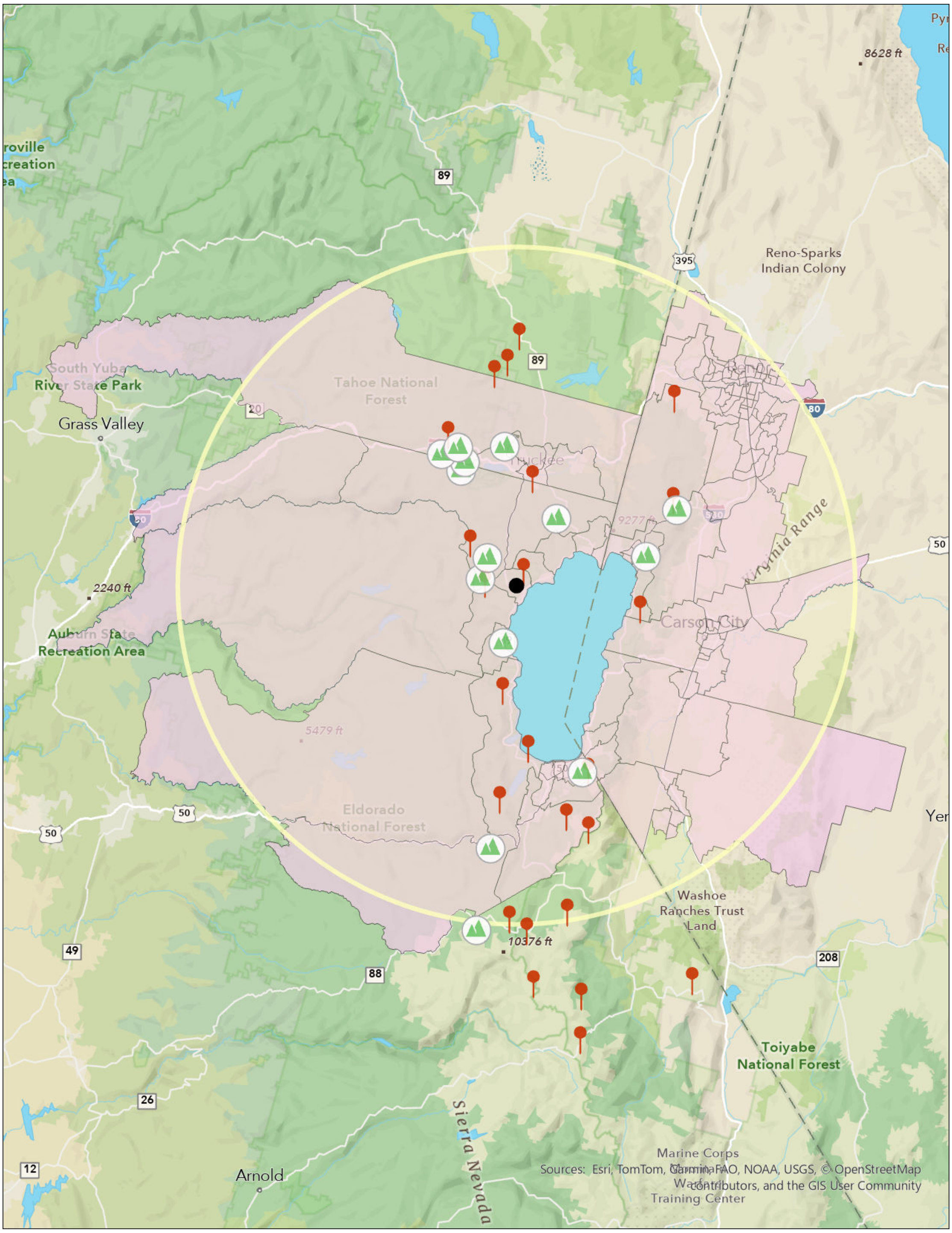

Figure 2 above depicts the geographic area analyzed in the study, focusing on the spatial relationships between ski resorts, weather stations, and Census tracts within a 35-mile radius. At the center of this area is a black dot, representing the focal point for all ski resorts, from which a yellow circle extends to delineate the 35-mile boundary. Within this radius, mountain icons mark the base lodges of ski resorts. Red pins indicate the locations of weather stations at elevations above 4,000 feet. The pink-shaded areas outline the individual Census tracts included in the analysis, each selected based on if its centroid fell within the radius.

Weather

Butsic, Hanak, and Valletta (2011) conducted a study to analyze the impact of changing weather conditions on skiing quality, which they used to understand how it affected the housing market. The researchers focused on the Snowfall Equivalent to Precipitation ratio (SFE/P), which they termed "snowfall intensity" (Butsic, Hanak, & Valletta 2011). This ratio indicates the proportion of winter precipitation falling as snow and is a more reliable measure than total snowfall, which is prone to measurement errors and observer biases (Knowles, Dettinger, & Cayan 2006; Cherry et al. 2005).

However, in the regression results discussed later, snowfall intensity was not statistically significant in predicting skiing quality and its associated impacts on housing prices. Therefore, I opted to use elevation as a variable instead of snowfall intensity. The data used in this study was sourced from the Snow Telemetry (SNOTEL) Network, which includes over 900 automated data collection sites located in remote, high-elevation mountain watersheds across the western United States. Elevation was measured as the average elevation of each Census tract. This measure is inherently correlated with snowfall intensity, as higher elevations generally receive more snow. Elevation is a useful indicator of whether snowfall is a significant factor for home buyers. This makes elevation a proxy for assessing the value that home buyers place on snowfall and skiing quality in these areas.

Ski Resort Characteristics

Ski resort characteristics can be essential for understanding the relationship between home prices and skiing conditions, as they impact the desirability of surrounding housing markets. Key factors such as resort size, skiable acreage, run variety and difficulty, season length, and available amenities like lodging, dining, and entertainment all enhance a resort's appeal. In Butsic, Hanak, and Valletta's (2011) regression analysis, they used two specific measures to reflect investments in resort capacity and quality: total lift capacity and average vertical drop (weighted by capacity). An increase in vertical drop is often seen as a quality improvement, as it offers the potential for longer runs and more diverse terrain. Butsic, Hanak, and Valletta (2011) measured lift capacity by considering ski resorts with at least a 1,000-person-per-hour capacity and a vertical drop of at least 500 feet.

In this paper's regression analysis, lift capacity and vertical drop will not be used, as data beyond Butsic, Hanak, and Valletta's (2011) study—which concluded in 2005—was not readily available. Additionally, when these ski area characteristics were included in Butsic, Hanak, and Valletta's (2011) preliminary regressions, the results proved to be statistically insignificant.

4. Results and Analysis

TABLE 1

Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
averagehmvalue	609	457134.09	196437.47	29609.121	947457.63
medianyrblt	609	1969.209	160.668	0	2015
avgrooms	609	5.101	1.097	1	7.764
popdenpersqml	609	1974.913	2840.196	0	19662.79
realmedincome	609	283.125	120.783	0	713.868
elv	609	8037.209	637.558	6242	8801
year	609	2020.062	1.503	2018	2022
tractid	609	2.640e+10	1.077e+10	6.017e+09	3.251e+10

The descriptive statistics presented in Table 1 and Table 2 provide an overview of the variables included in the regression analysis. They include measures of central tendency and variability, such as the mean and standard deviation, as well as the range for each variable. The variables include average home value in dollars (dependent variable), median year built, average number of rooms per housing unit**,** population density per square mile, real median income in dollars, average elevation in feet, year of observation, and Census tract identifier. This context will clarify how these variables contribute to housing prices in Lake Tahoe.

Table 2 provides the ordinary least squares regression results using data in their original level form, while Table 3 presents the analogous results with continuous variables transformed into natural log. Dummy variables, however, remain untransformed across both tables. Both tables incorporate a range of control variables to account for factors influencing housing values. Specifically, these controls include population density, the average number of rooms per house, average home size (not reported in the tables), real median income, elevation, and snowfall intensity (not reported in tables). Alternate regressions were run with average home size in place of average rooms and snow fall intensity in place of elevation. Both these alternate variables were insignificant. This double log model used in Table 4 has the convenient property that the coefficients of the continuous variables are also the elasticity of average home prices with respect to the independent variable in question. This approach allows for an assessment of the proportional relationships between the variables in Table 3, offering insights into elasticity and relative changes rather than absolute ones. An alternate dataset that pooled the years 2018- 2022 was estimated with tract and year specific fixed effects. The results were largely insignificant. Thus, I choose to report only the cross-sectional regression results here. All the regressions were tested for Heteroskedasticity, using the Breusch-Pagan test. Only the regressions in Table 4 exhibited heteroskedastic residuals. Thus, the results in Table 4 rely on Heteroskedastic robust standard errors. The results for this are shown in the Appendix.

The significant slope coefficients in Table 2 have their usual interpretation which is the impact on real average home prices for a unit change in the independent variable.

TABLE 2

realavghmvalue	2018 Coef.	2019 Coef.	2020 Coef.	2021 Coef.	2022 Coef.
Realmedincome	**5.775**	**4.178**	**3.561**	**1.639**	**2.433**
	(7.81) ***	**(6.88)*****	**(5.29)*****	**(4.09)*****	**(6.39)*****
Medianyrblt	**-19.613**	**-19.848**	**-1.197**	**-.356**	**-.583**
	(-4.94)***	**(-4.79)*****	**(-4.11)*****	**(-2.61)****	**(-2.83)*****
Avgrooms	**-184.047**	**-33.124**	**-35.312**	**671.186**	**68.558**
	(-2.48)**	**(-0.49)**	**(-0.40)**	**(7.65)*****	**(1.60)**
Popdenpersqml	**-.082**	**-.086**	**-.089**	**-.411**	**-1.049**
	(-6.09)***	**(-6.30)*****	**(-4.52)*****	**(-0.55)*****	**(-7.28)*****
Elv	**-.03**	**-.101**	**-.094**	**.088**	**-.114**
	(-0.48)	**(-1.61)**	**(-1.16)**	**(1.42)**	**(-2.27)****
Constant	**40362.06**	**41080.103**	**4271.81**	**-856.227**	**3030.858**
	(5.24)***	**(5.11)*****	**(5.41)*****	**(-1.29)**	**(5.37)*****
R^2	**0.518**	**0.664**	**0.647**	**0.769**	**0.674**
n	**127**	**127**	**97**	**97**	**161**

****** p<.01, ** p<.05, * p<.1***

In Table 2 above, real median income shows a consistently positive and significant effect, with p-values below 0.01 each year, particularly notable in 2018 and 2019. This indicates that as median income rises, home values also increase, underscoring a strong correlation between household wealth and housing prices. The positive impact of median income on home values reflects fundamental economic principles of supply and demand.

The consistent negative coefficient for the median year built variable across all years underscores a clear trend in the Lake Tahoe region: newer homes are generally associated with lower average home values. This suggests that older homes, with their historical appeal, unique architecture, and prime locations, often command higher prices. In areas like Lake Tahoe, where land for new development is limited, older properties become more desirable due to their scarcity and proximity to local amenities, cultural sites, or natural attractions. From 2018 to 2022, this trend reveals a sustained preference for homes with historical character, signaling long-term investment value to buyers. However, the coefficients for real median income in 2020-2022 declined when compared to their values in 2018 -2019, indicating a decrease in the value of historic properties.

In keeping with Butsic, Hanak and Valetta (2011), I also find a significant and negative relationship in 2018 between the average number of rooms and real average home prices. The impact of the average number of rooms on home values fluctuates notably over time, reflecting broader economic shifts and changing buyer preferences. In 2018 and 2019, the relationship between room counts and home values is negative but weak, indicating that home size was not a primary driver of value during these years, possibly due to stable economic conditions and steady housing demand. However, in 2020, the effect becomes highly significant and positive, driven by a pandemic-fueled demand for larger homes as households sought additional space for remote work, schooling, and recreation. By 2021 and 2022, this effect begins to diminish, suggesting that the intense demand for more spacious homes was closely tied to the unique economic and social conditions of the pandemic, including temporary increases in disposable income, low interest rates, and widespread adoption of remote work. As these conditions began to normalize, buyers may have recalibrated their housing needs, reducing the urgency for additional space.

Population density per square mile shows a consistently negative and significant relationship with home values across all years, underscoring a clear economic preference for lower-density and more scenic areas, which are characteristics of Lake Tahoe. This trend was particularly strong in 2020 and 2021, when pandemic-driven lifestyle changes increased demand for spacious, less crowded environments, enhancing the desirability of low-density properties. This is supported by the increase in the absolute value of the population density coefficient over time.

Elevation, while mostly insignificant throughout the study period, shows a weakly significant negative impact on home values in 2022. This suggests that in specific years, higher elevations— associated with accessibility challenges, harsher weather conditions, or increased travel costs—can detract from a property's appeal. However, as this effect was not consistent in other years, it indicates that elevation is a context-dependent factor whose influence may fluctuate based on broader economic conditions, such as transportation costs or the appeal of remote work.

Snowfall intensity, though not directly reported in the study, can possibly be shown as a critical factor. Although snowfall is often associated with elevation, the relationship with housing prices remains consistent across the years. In general, increased snowfall intensity does not significantly impact housing prices. This could be because all of the tracts in this dataset get at least some snow. However, alternate regressions which used snowfall intensity instead of elevation showed significance in the 2022 dataset. 2022 was one of the largest snow seasons on record. This unusually high snowfall contributed to a decline in housing prices, as extreme weather can deter buyers. The lack of significance in other years, which experienced lower snowfall levels, further highlights that only exceptionally high snowfall appears to impact housing demand and values.

The constant term, which represents the base level for home values, generally remains high and significant, with a notable dip in 2021 that may reflect market volatility or pandemic-related disruptions. Overall, the analysis supports the thesis that economic factors and housing characteristics significantly influence home values in Lake Tahoe. The strong link between income and home values underscores the role of affluent buyers in these markets, often tied to tourism. Additionally, the preference for larger homes in 2020 reflects pandemic-related shifts in housing demand. Finally, the negative relationship between median year built and home values suggests that older homes, often with unique characteristics, hold a premium, in line with hedonic pricing theory. These findings collectively affirm that income levels and home characteristics, like size and age, are key determinants of housing prices in Lake Tahoe.

The regression model above, which is conducted in level form, provided insights into the unit impacts of various factors on home values. In keeping with Butsic, Hanak, and Valletta (2011) I ran a double-log model regression. This log-log model yields coefficients that are the elasticities of real average home prices with respect to each continuous independent variable. The regression results for the natural logarithm of real average home values provide a percentage-based view of how key variables influence housing prices from 2018 to 2022. Analyzing the data in log form allows each coefficient to be interpreted as an elasticity, showing the percentage change in home values for a 1% change in each variable.

TABLE 3

lnrealavghmval	2018 Coef.	2019 Coef.	2020 Coef.	2021 Coef.	2022 Coef.
lnrealmedincome	1.05	1.072	.725	.4	.219
	(6.75)***	(8.36)***	(4.58)***	(3.70)***	(1.99)**
lnmedianyrblt	-19.485	-20.77	-21.271	-15.395	-5.816
	(-3.68)***	(-5.18)***	(-3.68)***	(-2.77)***	(1.59)
lnavgrooms	-.38	-.414	.475	1.868	.493
	(-1.13)	(-1.37)	(1.09)	(5.72)***	(2.29)**
lnpopdenpersqml	-.065	-.073	-.076	-.176	-.167
	(-3.59)***	(-0.27)***	(-3.68)***	(-2.64)***	(-5.60)***
lnelv	-.193	-.042	.028	.68	-.152
	(-0.50)	(-0.13)	(0.06)	(2.25)**	(-0.54)
Constant	152.191	160.599	164.23	114.563	51.71
	(3.93)***	(5.42)***	(3.85)***	(2.79)***	(1.93)*
R^2	0.584	0.643	0.610	0.733	0.551
n	127	125	95	94	153

****** p<.01, ** p<.05, * p<.1*

The regression results for the natural logarithm of real average home values provide a percentage-based view of how key variables influence housing prices from 2018 to 2022, shown in Table 3 above.

The results in Table 3 show how the use of logged terms shifts the focus from absolute changes in home values to the elasticities of various factors. Both Table 2 and Table 3 consistently show a positive and highly significant relationship between income and home values across all years, indicating that higher incomes are strongly associated with higher home values. Additionally, the coefficient for population density is negative and significant in both tables, suggesting that increased density correlates with lower home values. Both tables also reveal a negative relationship between the median year a property was built and home values, implying that newer properties tend to have higher values overall.

The tables do display some differences, which center on the significance of certain variables across the years and how the coefficients are interpreted. The effect of the average number of rooms varies between the two tables: while Table 2 shows a positive relationship with home values only in 2021, Table 3 extends this positive relationship to both 2021 and 2022. Similarly, elevation has a brief significant positive effect in 2021 in Table 3, in contrast to its largely insignificant role in Table 2. Finally, Table 3 generally shows higher R-squared values, indicating that the logged model provides a slightly better fit for the data overall.

5. Conclusion

The results reveal how economic and locational factors interact to shape Lake Tahoe's unique real estate market. By examining both level and double log functional forms, the study offers a comprehensive understanding of how variables such as median income, home age, room count, average household size, population density, elevation, and snowfall intensity influence home values over time. The results show that overall real average housing prices are influenced positively and significantly by real median income and negatively by population density and newer construction. The significant effects of variables like average room count during the pandemic years of 2020 and 2021 suggest that preferences for larger homes contributed to price increases. The results on age of the home and elevation are mixed.

The regression further indicates that low population density is a consistently valued attribute, with buyers willing to pay premiums for homes in less crowded, scenic areas typical of mountain towns. This preference reinforces a sustained demand for properties that offer privacy and proximity to natural amenities, both of which are limited in supply. The scarcity of these desirable locational attributes, coupled with rising incomes, amplifies the upward trajectory of housing prices.

The results should be interpreted with the following caveats in mind. One notable drawback is the inclusion of every census tract within a 35-mile radius. Some portions of certain tracts extend beyond the 35-mile radius, as Census tract data cannot be divided. This may result in some outlying data points. Relying on census data also introduces a lag in reflecting real-time market conditions, potentially missing recent shifts influenced by economic changes or natural events. Lastly, omitted variables such as environmental quality may skew the results, attributing unexplained variations to included factors. These limitations suggest that while the regression offers a broad understanding of the market, further research with more localized, tourism-specific data and real-time indicators would refine the model and enhance its accuracy.

The results demonstrate that the combination of rising incomes, changing consumer preferences in recent years for an increasing number of rooms or home size, and the ongoing appeal of low-density areas contribute to escalating housing prices.

References

Bajari, P., & Benkard, C. L. (2005). Demand estimation with heterogeneous consumers and unobserved product characteristics: A hedonic approach. *Journal of Political Economy, 113*(6), 1239-1276. doi:10.1086/498585

Berger, M. C., Blomquist, G. C., & Peter, K. S. (1988). Compensating differentials in emerging economies. *Journal of Urban Economics, 24*(2), 112-126. doi:10.1016/0094-1190(88)90019-8

Blevins, J. (2023). Colorado mountain towns see home prices soar as locals feel the squeeze. *The Denver Post.* https://www.denverpost.com/

Blanco, A., & Cheer, J. M. (2018). The Airbnb effect: Impacts on housing and tourism markets. *Tourism Geographies, 20*(5), 763-776. doi:10.1080/14616688.2017.1415314

Burakowski, E., & Magnusson, M. (2012). Climate impacts on the winter tourism economy in the United States. *Natural Resources Defense Council.* https://www.nrdc.org/

Bureau of Labor Statistics. (n.d.). *Consumer Price Index: All urban consumers.* https://www.bls.gov/cpi/

Butsic, V., Hanak, E., & Valletta, R. G. (2011). Climate change and water demand for skiing: Economic impacts on ski resorts in the Western United States. *Journal of Environmental Management, 92*(9), 2544-2552. doi:10.1016/j.jenvman.2011.04.014

Can, A. (1992). Specification and estimation of hedonic housing price models. *Regional Science and Urban Economics*. https://doi.org/10.1016/01660462(92)90039-4

Cheshire, P., & Sheppard, S. (1995). On the price of land and the value of amenities.

Economica, 62(246), 247-267. doi:10.2307/2555032

Chin, T. L., & Chau, K. W. (2003). A critical review of literature on hedonic pricing models. *International Journal for Housing Science and Its Applications*

Dundas, R. (2023). Tahoe housing market changes amidst rising prices and climate challenges. *Tahoe Daily Tribune.* https://www.tahoedailytribune.com/

Fortune. (2023). Why rising home prices are creating a housing affordability crisis in Lake Tahoe. https://www.fortune.com/

Gyourko, J., & Tracy, J. (1991). The structure of local public finance and the quality of life. *Journal of Political Economy, 99*(4), 774-806. doi:10.1086/261778

Gurbuz, I. (2024). Climate projections for Lake Tahoe's winter season. *Environmental Research Letters*. https://iopscience.iop.org/

Hamilton, L. C., Brown, C., & Keim, B. D. (2007). Ski areas, weather, and climate: Time series models for New England case studies. *International Journal of Climatology, 27*(15), 2113-2124. doi:10.1002/joc.1492

Harrison, D., & Rubinfeld, D. L. (1978). Hedonic housing prices and the demand for clean air. *Journal of Environmental Economics and Management, 5*(1), 81 102. doi:10.1016/0095-0696(78)90006-2

Hedges, G. (2023). Workforce housing challenges in Western ski towns. *High Country News.* https://www.hcn.org/

Lake Tahoe Property Report. (2022). Analysis of property features and values in Lake Tahoe. *Lake Tahoe Real Estate Database.* https://www.laketahoerealestate.com/

McCusker, P., & Hess, J. (2018). Climate change impacts on ski resorts in the Lake Tahoe region. *Journal of Mountain Research, 5*(3), 229-245. doi:10.1007/s11629-018-4875-9

Meltzer, R., & Cheung, R. (2014). Household demand for housing and neighborhood amenities in U.S. urban areas. *Journal of Urban Economics, 82*, 1-9. doi:10.1016/j.jue.2014.04.003

National Association of Realtors. (2021). *Home prices hit record high.* https://www.nar.realtor/

OECD. (2007). Climate change and tourism policy in OECD countries. *Organisation For Economic Co-operation and Development.* https://www.oecd.org/

Pace, R. K., & Gilley, O. W. (1997). Using the spatial configuration of the data to Improve estimation. *Journal of Real Estate Finance and Economics, 14*(3), 333-340. doi:10.1023/A:1007753514314

Palmquist, R. B. (1984). Estimating the demand for the characteristics of housing. *The Review of Economics and Statistics, 66*(3), 394-404. doi:10.2307/1924995

Redfin. (2024). Real estate market trends for Western U.S. ski towns. https://www.redfin.com/

Rosen, S. (1974). Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition. *Journal of Political Economy*, *82*(1), 34–55. http://www.jstor.org/stable/1830899

Scott, D., McBoyle, G., & Mills, B. (2007). Climate change and the sustainability of ski-based tourism in Eastern North America: A reassessment. *Journal of Sustainable Tourism, 15*(4), 376-398. doi:10.2167/jost605.0

Simard, C. (2023). Income and housing price trends in U.S. mountain towns. *U.S. Bureau of Economic Analysis.* https://www.bea.gov/

SNOTEL (n.d.). Resources Conservation Service. https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/water/snowsurvey

Tahoe Demographics. (2021). Socioeconomic indicators for Lake Tahoe communities. *Tahoe Regional Planning Agency.* https://www.trpa.org/

Tahoe Open Data. (2022). Housing occupancy rates in Lake Tahoe. *Tahoe Open Data Platform.* https://www.open.tahoe.gov/

Taylor, L. O. (2003). The hedonic method in real estate and environmental economics. *Journal of Economic Perspectives, 17*(2), 111-132. doi:10.1257/089533003765888474

Taylor, L. O., & Smith, V. K. (2000). Environmental amenities as a source of market power. *Land Economics, 76*(4), 550-568. doi:10.2307/3146967

U.S. Census Bureau. (n.d.). *About the U.S. Census Bureau*. https://www.census.gov/about/what.html

Workforce Housing Report. (2023). Housing market dynamics and workforce implications in ski towns. *Mountain Housing Council of Tahoe Truckee.* https://www.mountainhousingcouncil.org/

Appendix: Testing For Heteroskedasticity

Level Form Heteroskedasticity Test Results

2018

estat hettest

Breusch–Pagan/Cook–Weisberg test for heteroskedasticity
Assumption: Normal error terms
Variable: Fitted values of realavghmvalue

H0: Constant variance

chi2(1) = 3.21
Prob > chi2 = 0.0734

2019

estat hettest

Breusch–Pagan/Cook–Weisberg test for heteroskedasticity
Assumption: Normal error terms
Variable: Fitted values of realavghmvalue

H0: Constant variance

chi2(1) = 0.14
Prob > chi2 = 0.7101

2020

estat hettest

Breusch–Pagan/Cook–Weisberg test for heteroskedasticity
Assumption: Normal error terms
Variable: Fitted values of realavghmvalue

H0: Constant variance

chi2(1) = 0.23
Prob > chi2 = 0.6281

2021
estat hettest

Breusch–Pagan/Cook–Weisberg test for heteroskedasticity
Assumption: Normal error terms
Variable: Fitted values of realavghmvalue

H0: Constant variance

chi2(1) = 1.35
Prob > chi2 = 0.2450

2022
estat hettest

Breusch–Pagan/Cook–Weisberg test for heteroskedasticity
Assumption: Normal error terms
Variable: Fitted values of realavghmvalue

H0: Constant variance

chi2(1) = 0.62
Prob > chi2 = 0.4299

Double Log Form Heteroskedasticity Test Results
2018
estat hettest

Breusch–Pagan/Cook–Weisberg test for heteroskedasticity
Assumption: Normal error terms
Variable: Fitted values of lnrealavghmval

H0: Constant variance

chi2(1) = 25.69
Prob > chi2 = 0.0000

2019
estat hettest

Breusch–Pagan/Cook–Weisberg test for heteroskedasticity
Assumption: Normal error terms
Variable: Fitted values of lnrealavghmval

H0: Constant variance

chi2(1) = 21.60
Prob > chi2 = 0.0000

2020
estat hettest

Breusch–Pagan/Cook–Weisberg test for heteroskedasticity
Assumption: Normal error terms
Variable: Fitted values of lnrealavghmval

H0: Constant variance

chi2(1) = 30.20
Prob > chi2 = 0.0000

2021
estat hettest

Breusch–Pagan/Cook–Weisberg test for heteroskedasticity
Assumption: Normal error terms
Variable: Fitted values of lnrealavghmval

H0: Constant variance

chi2(1) = 39.57
Prob > chi2 = 0.0000

2022
estat hettest

Breusch–Pagan/Cook–Weisberg test for heteroskedasticity
Assumption: Normal error terms
Variable: Fitted values of lnrealavghmval

H0: Constant variance

chi2(1) = 40.08
Prob > chi2 = 0.0000