THE EFFECTS OF POPULATION DENSITY ON HOME PRICES

A Thesis

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Ryan G. Sharpe

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Department of Public Policy and Administration

ABSTRACT

of

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by

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Residents, home buyers, planners, and elected officials have differing ideas about how much a home value is changed by potential increases in density due to new development or how much of a premium is placed on the seclusion afforded by lower-density neighborhoods or the amenities offered by higher-density neighborhoods. Existing literature largely only probes the nature of any relationship between home prices and population or residential density in a simple way and as a control for other possible relationships.

Using a dataset provided by the Sacramento Association of Realtors that includes over 10,000 home sales in Sacramento County, California over three months in 2013 and four months in 2016, and neighborhood data from the U.S. Census Bureau, this study conducts a hedonic price estimate to test whether a quadratic relationship between home prices and population density exists, controlling for other home, neighborhood, and sales factors.

The results indicate that home prices are higher in both dense urban neighborhoods and sparse rural neighborhoods than in middle-density suburban neighborhoods.

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Date

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1. INTRODUCTION

There is a lot of advice posted to real estate blogs and media intended to help home buyers look for “a good deal” or traits that could command a premium for sale or resale. While some of these traits – accent wall colors, for example – could be changed fairly easily, some could not. As a researcher, those pieces of advice that pointed to what *neighborhood* would be good seemed particularly interesting, as it is not a trivial process to move a home from one neighborhood to another. The advice I saw was often in conflict with itself, with exhortations to buy in the suburbs for a backyard and privacy and also to buy in an urban environment to enjoy walkable amenities and an active life. How exactly do home buyers value dense urban environments as compared to sparser suburbs and exurbs?

These questions about the effects of increasing density are important not just to home buyers, but also to urban planners and decision makers who must develop or approve plans to build up an urban environment or spread homes across a newly available green field. Further knowledge of what the effects of density are can help us make better decisions about where to put new homes and apartments to better reach goals of greenhouse gas reduction or improved mobility – or the value of the homes in neighborhoods. As this study answers the latter question, it provides another piece of information that can prove crucial to the fields of planning and development.

WHY DOES DENSITY MATTER?

Density is typically measured as the number of housing units (residential density) or people (population density) in a given area. As more units are built or as more people move into an area, density increases. This increase often becomes a direct point of contention between neighborhood activists who may want to see their neighborhoods maintain specific design, congestion, or population characteristics and smart growth or New Urbanist advocates and planners who see increases in density as a way to provide greater transportation, utility, and civic services to a larger population with greater economies of scale. This relationship and tension between housing prices and density also appears in statements and positions taken by neighborhood and preservation activists, real estate watchers, and planners, often during political discussions about proposed projects. Lewyn (2012) lays out one of these arguments: by increasing density, a neighborhood becomes too desirable, thereby leading to higher rents and home prices. Real estate watchers try to dispel this “myth” and point out that high-density developments bring benefits to their neighborhoods such as a decrease in vehicles miles traveled and an increase in retail and restaurant opportunities (Rebchook, 2013). Even the Finance Authority of the Association of Bay Area Governments (1997) waded into the fray, republishing in its entirety a 1993 California Planning Roundtable information sheet detailing myths and facts about affordable and high-density housing and poking holes in the common activist arguments that such development will strain public services, increase crime, and reduce property values. Home price literature further emphasizes this point, with Myers and Gearin (2001) describing a distinct shift in the market towards centrally-located housing and Tu and Eppli (1999) finding that houses in a new mixed-use, dense development commanded a 12% premium over suburban development nearby.

This tension exists within my study area. For example, a recently-approved project in Sacramento, California would involve erecting a 14-story mixed-use residential and retail tower in an area near the city center characterized by two- and three-story shops and residences. Neighborhood and preservation activists largely used technical language about conformance with zoning height allowances and maximum density allowances to object to the addition of 134 condominium units in the area (Burg, 2016), while a city councilmember specifically praised the addition of more housing available for sale in the urban core, both to increase housing availability and for its air quality benefits (van der Meer, 2016).

DENSITY IN REAL ESTATE MEDIA

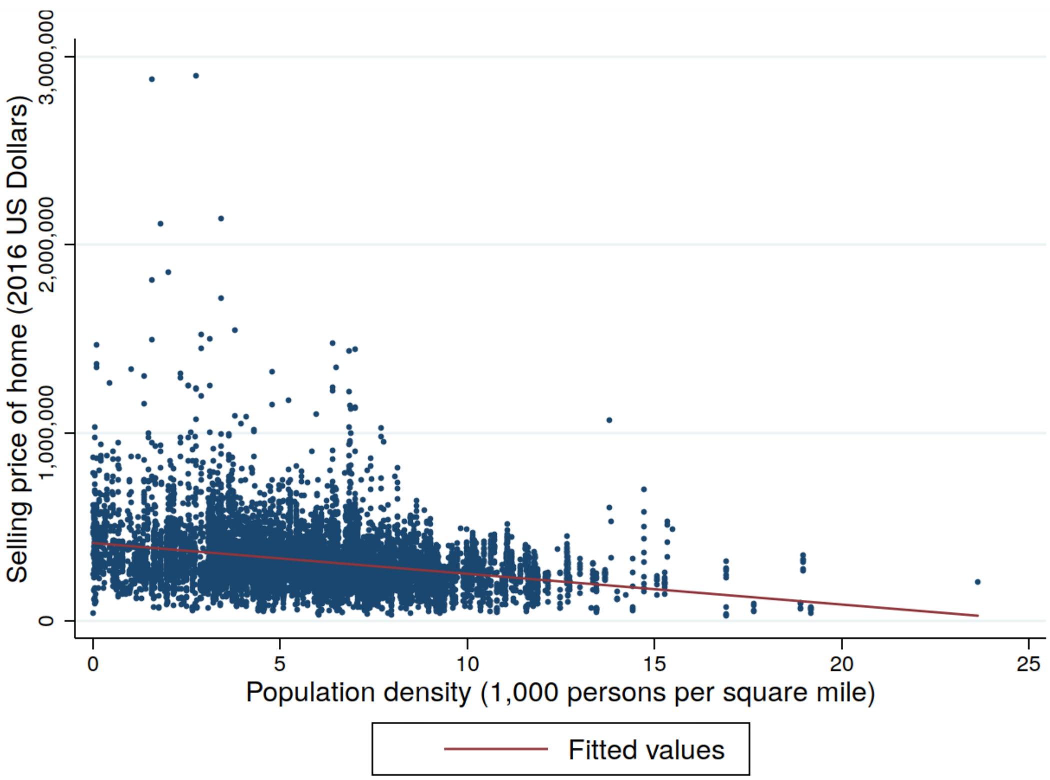
According to real estate media, homebuyers look for certain traits in homes they may purchase, particularly locations allowing for large yards, proximity to amenities, safe neighborhoods, good schools, and good transit options or routes to work (Fontinelle, n.d.; Pan, 2016). While it stands to reason that desired features like these would command a higher price for a home, they are not always compatible. For example, a home in an exurban neighborhood composed of single-family houses on one-acre lots is not likely to be walking distance from schools, libraries, or stores. Conversely, a third-floor condo in a bustling urban center may not offer the “peace and quiet” a potential buyer may be looking for. Independent of home characteristics such as lot size, does a neighborhood’s density affect prices, how does it do so, and is there a tilt towards more-dense or less-dense neighborhoods that provide these different styles of development?

Existing literature also points to home prices increasing due to proximity to open spaces, a common feature of low-density development. Irwin (2002) shows that open space near a property contributes to higher property values as an indication that the lack of development is itself highly valued, in part due to greater recreational opportunities. Similarly, Luzenhiser and Netusil (2001) find that open spaces have a positive effect on home prices, even in urban areas like Multnomah County, Oregon. Karkoski (2009) also found that after controlling for home characteristics and other variables, proximity to a large regional parkway contributed to an increase in home prices between 10% and 40% in Sacramento County, California.

QUANTITATIVE ANALYSIS

To test the connection between density and home prices, I use a hedonic price estimate – a form of statistical regression analysis that uses a home's selling price as a *de facto* measure of the value placed on the various traits a home possesses – to examine a dataset of homes sold in Sacramento County over seven months for which Multiple Listing Service data is available. My dataset includes data from over 10,000 homes and their neighborhoods to determine how much of an effect density has on the home's sale price, all else held equal. Sacramento County is an appropriate region to study, as it has an active housing market and is a fairly large and diverse county, comprising a typically dense urban core, suburbs of varying age and density, exurban development, and rural land. My dependent variable is the final selling price of the home in 2016 dollars and my key explanatory variable is the population density of the census block group that home is within. Figure 1 presents a glimpse into the relationship between these two variables, absent any controls for the effects of any other factors on a home's selling price.

Figure 1: Graph of population density and selling prices in Sacramento County



(Wassmer, 2017; U.S. Census Bureau, 2011, 2017a)

HYPOTHESIS AND STRUCTURE

I hypothesize that the density of a neighborhood influences the price of homes within, with home prices increasing at both lower and higher densities, as some buyers place a higher value on open space and others place a higher value on urban living. As a result, neighborhoods in the middle of the density range will have a lower price.

I divided this paper into five sections. Section I is this introduction, providing the theoretical background for the rest of the paper and a description of the intent of this research. Section II is a review of the academic and planning literature related to population density and home prices that will uncover how researchers view the relationship and how it affects the planning profession. Section III is a quantitative analysis of density and home prices, using a hedonic price estimate to assess the true relationship between the two variables in Sacramento County. Section IV is a qualitative analysis of interviews with practicing urban planners in public service to determine how the planning profession views the effects of density on home prices. Section V concludes the paper and will offer summaries of all findings.

2. LITERATURE REVIEW

The hedonic method is a form of regression analysis that aims to uncover the effect of a given characteristic on a home's value, thereby providing a dollar value for what that characteristic contributes to the total selling price of a home in general. Such an analysis would help extend the real estate agent's mantra, going from "location, location, location" to include just how much location matters as opposed to other traits like the quality of the local school district or the depth of an in-ground pool. Given the significant rise in home prices in urban centers in recent years as well as a perceived premium for life in further suburbs, "away from the crowds," I am interested in whether the density of a neighborhood has any effect, and if so, how much.

The literature review to follow will briefly provides an overview of hedonic price estimates and the elements common to these types of study, then describe three major categories of difference. The three categories compose three of the four themes of this literature review. The first theme is how a regression study measures density and whether the measurement used was directly from available data or calculated from some other method. The second theme is the geography studied by each regression analysis, detailing the benefits of a county-level review relative to a larger or smaller study area. The third theme is the use of two common sources of data: the U.S. Census and geographic information systems (GIS), which can provide spatial analysis of individual properties. A fourth important theme is a review of planning literature to identify how the planning profession considers density. The section concludes with a summary of lessons drawn from these themes that I will apply in my own regression and interview based analyses.

HEDONIC PRICE ESTIMATES

All the studies in this review were hedonic price estimates of homes in a large, predominantly urban county or region. To perform the regressions required, researchers used the home selling price – usually in a natural logarithmic form– as a dependent variable. Most studies used a logarithmic form to calculate the expected percent change in decimal form in the dependent variable for each unit of the explanatory variable (Bohman & Nilsson, 2016; Cho et al, 2006; Clark & Herrin, 2000; Lynch & Rasmussen, 2001; Song & Knapp, 2003). Others used a straight linear form (Li & Brown 1980; Shultz & King, 2001), which does not take the natural log of the dependent variable and therefore the calculated regression coefficient on a given explanatory variable measures the change in the sales price of a home give a one-unit change in the explanatory variable. Only one study (Dunse et al, 2013) was found that used a quadratic form for density, which makes per-unit changes difficult to interpret and instead identifies whether the results describe a convex curve with values converging on a minimum, or a concave curve with values converging on a maximum. Quadratic forms are uncommonly used in hedonic price estimates of homes. They have predominantly been used for explanatory variables other than density, such as quadratic analysis of five types of open space (Lutzenhiser & Netusil, 2001) and of acreages of preserved ranchland (Rosenberger & Walsh (1997).

Control characteristics chosen were usually broken into categories of traits inherent to the property, such as the nature of the structure and lot; traits inherent to the area, such as a neighborhood's socioeconomic status; and occasionally the public services and/or amenities available to a home in that particular area. Dependent on the specific factor of researcher interest, regressions also contained neighborhood-specific measures like crime rate (Lycnh & Rasmussen, 2001) or public school achievement (Clark & Herrin, 2000) to see how it independently affected home prices.

All but one of these studies included a variable for the density of the region surrounding the house, which I will further explain in the following section. While all studies found statistical significance in their test variable, results for the effect of density on home prices were for the most part significant, negative and of negligible magnitude; finding -0.0000079%per additional person per square mile (Clark & Herrin, 2000) in studies using population density and from approximately -0.023% (Shultz & King, 2001) to 0.1% (Cho et al, 2006) per additional housing unit per acre in studies using housing density. Table 1 offers a summary of the studies considered in this review and provides the primary subject of each study, how it measures density, the geography studied, the functional form taken of the density measure in the study, the results of the density regression, and the categories of other independent variables used.

Table 1: Summary of regression studies reviewed

Study	Primary subject	Density type Density measurement	Geography studied	Dependent variable	Results for density	Independent variable categories
Bohman & Nilsson (2016)	Regional commuter trains	Housing density Unspecified population density metric	Scania Region, Sweden	ln(Selling price)	-0.8% change in home value for a median-priced home for each additional person in a municipality Significant at 1%	Property Neighborhood
Cho, Bowler, & Park (2006)	Proximity to water bodies and open space	Housing density Houses per acre	Knox County, Tennessee	ln(Selling price)	0.1% change in home price for each additional house per acre Significant at 1%	Structure Census Block Group High School Political Jurisdiction Distances Other
Clark & Herrin (2000)	School quality	Population density People per square mile (census tract)	Fresno County, California	ln(Selling price)	-0.0000079% change in home value for each additional person per square mile Significant at 1%	Structure Neighborhood Year of sale
Dunse, Thanos, & Bramley (2013)	Housing density	Housing density Dwellings per hectare	Five case study areas in England	Selling price Selling price (squared)	Concave relationship in urban areas Convex relationship in suburban areas	General housing characteristcs
Li & Brown (1980)	Air and noise pollution	Housing density Housing units per square mile	Southeastern Boston, Massachusetts metropolitan area	Selling price	0.083%[2] change in home price for each additional housing unit per square mile Not significant	Structure Neighborhood Public Services Microaccessibility
Lynch & Rasmussen (2001)	Crime	N/A	Combined city/county of Jacksonville, Florida	log(Selling price)	N/A	Structure and Lot Neighborhood

Study	Primary subject	Density type Density measurement	Geography studied	Dependent variable	Results for density	Independent variable categories
Shultz & King (2001)	Open space	Housing density Single-family dwellings per acre	Tucson, Arizona	Selling price (Estimated from Census data)	-0.023%[1] change in home value for each additional housing unit per acre Significant at 1%	Structure Neighborhood Market
Song & Knapp (2003)	New Urbanism characteristics	Housing density Number of single-family residences divided by area of neighborhood Number of households divided by area of neighborhood	Washington County, Oregon	ln(Selling price)	-0.863% change in home value for each additional person per square mile Significant at 1%	Property Public Services Amenities Socioeconomics

[1] Calculated from findings of -$2,745 divided by median Arizona home price in 2000 of $121,300 (U.S. Census Bureau 2017b)

[2] Calculated from findings of $4,000 divided by median Massachusetts home price in 1980 of $48,400) (U.S. Census Bureau 2017b)

Density measurements

Researchers and policymakers typically record population density in terms of population per area, often square mile in studies from the United States. To provide a sense of scale, New York City exhibited an overall density of 27,000 residents per square mile in 2015 (New York City, 2016). Clark and Herrin (2000) used Census data for people per square mile, taken at the census tract level. Bohman and Nilsson (2016) relied upon Sweden's National Land Survey (Lantmäteriet) measurement of population density. Despite using U.S. Census data in other variables in their analysis, Song and Knapp (2003) used a separate measurement of households per neighborhood area as a proxy for a direct measurement of the population density.

Not all studies relied upon population density. Shultz and King (2001), Cho et al (2006), Dunse et al (2013), and the seminal Li and Brown (1980) used a level of residential housing density in their studies, measuring the number of single-family dwellings, houses, or housing units per area, respectively. This metric has the advantage of being easy to collect from non-Census sources (particularly for the pre-Internet research of Li and Brown, 1980) and very likely tracks closely to direct measurements of population density, but introduces a potential disconnect between the measurement of density and the home price under study. This possible source of error is likely insignificant, given the intent of most of these researchers to focus on something other than density.

Geography studied

The reviewed studies varied in the scale of the region they encompassed. As the study area increases in size, it increases the possible number of observations, improving the ability to gain statistical significance. A larger study area also brings with it a need for more controlling variables, given the likely increase or introduction of more land uses, amenities, or other possible variables that may influence a home's selling price and complicate a regression.

Most studies in this review limited themselves to a county level or around a sub-region made up of multiple jurisdictions. Song & Knapp (2003) studied Washington County, Oregon, capturing only a fragment of the greater Portland metropolitan area, choosing that county because it is part of the New Urbanist-inspired growth boundary surrounding Portland while still offering a variety of land uses and transportation infrastructure to compare. Li & Brown (1980) studied home sales in 15 towns in the southeastern section of the Boston metropolitan area. Similarly, Dunse, et al used case studies from five *a priori*-selected geographic areas of England. Cho, et al (2006) reviewed Knox County, Tennessee with the intention of identifying the value of the open space, given new encroachments by the city of Knoxville upon open river and wild land. Finally, Clark & Herrin (2000) analyzed Fresno County, California used the multijurisdictional aspect of their county-level data to gauge the effect of the school district a home is located in on its sale price.

Of all the studies reviewed, only one exceeded a county in its scope: Bohman and Nilsson's 2016 review of the effect of regional commuter trains in the Scania region of Sweden. Given the study subject, a regional review that could encompass several said commuter trains would be useful, if not necessary. Two studies relied on data from a single city. Lynch and Rasmussen (2001) studied the combined city/county of Jacksonville, Florida and Shultz and King (2001) studied Tucson, Arizona. Limiting the scope to a single political jurisdiction allows the researcher to hold some political and regulatory effects constant; use of countywide data may require controlling in order to run a proper regression in order to tease out the effects of separate zoning laws, tax districts, and other civic amenities within subjurisdictions.

One concern of the choice of geography used is the aggregation of subareas that present radically different effects than at the individual level. The findings by Dunse, et al (2013) specifically point to this possibility. By focusing on five separate geographic regions and looking for quadratic relationships between prices and density, the researchers identified that these relationships are not only different for different areas, but contradictory. In that study, urban locations near London showed a home prices on the density curve moving downward from a theoretical maximum price and suburban locations with the inverse finding, all independent of other home or neighborhood characteristics. A simple linear or logarithmic regression would result in findings that tried to average these two findings and failed to capture the effects of local density on prices.

Data collection

The studies varied in their methods of data collection, with data often coming from the U.S. Census Bureau or from GIS in their analyses. Census data is crucial for the researcher seeking data about socioeconomic or other neighborhood factors, and comes in three hierarchal levels of granularity: the smallest being the census block, which roughly coincides with a city block; the next size up being the block group, a collection of several adjacent blocks; and larger still the census tract. This level of data granularity can be a source of concern for researchers. Finer scrutiny, such as at the block level, may fail to account for effects from the larger neighborhood or an adjoining one, while coarser scrutiny may fail to yield useful results, given the heterogeneity of land uses at levels of a census tract or larger. Shultz and King noted this distinction and the difficulty presented by census block-level or census tract-level analysis, instead preferring the middle level: the census block group (2001). Clark and Herrin (2000) used census data to compare the effects of commute time, racial population percentages, median incomes, and private school enrollment in their regressions. Cho et al (2006) gathered median housing values, housing density, commute times, per-capita incomes, unemployment rates, and vacancy rates from census data. Lacking direct home sale price data gathered by other researchers from multiple listing service (MLS) or third-party or commercial data sources, Shultz and King (2001) took advantage of U.S. Census Bureau decisions to publish block-level data and provide spatial geo-referencing from 1990 onward to estimate house sales prices and test whether a census-derived sales price could stand in for the sale prices from proprietary commercial sales data for the purposes of a hedonic price study.

GIS, by contrast, allows a researcher to use spatial relation to measure distances and more accurately calculate and compare land uses and their effect on a property. Song and Knapp (2003) used GIS to quantify the New Urbanist features they were seeking, using linear measures of street networks; street network interconnectivity; distances to nearby commercial uses, bus stops, and parks; land use density and mixes; and even the distance of a house from the end of a cul-de-sac. This supplemented the use of traditional census data measures such as the racial makeup of a neighborhood or its median income. Lynch and Rasmussen (2001) used a hybrid approach, taking an average of neighborhood characteristics at the census block group level for all of the block groups within a specified distance of their observed homes.

Findings in hedonic price literature

As described earlier, hedonic price estimates can vary widely in terms of the measurement of some variables, such as neighborhood density; as well as in the size of the area under study and the tools available to collect data. However, the crucial element remains a home's selling price, which provides the central object (change in market price) sought in the analysis. While there is an ability to use new GIS and spatial data from the U.S. Census in addition to the availability since 1990 of Census data at the census block level, most research still tends to use data ranges in the middle of the available sets. This takes the form of county data for geographic scope and census block groups when using census data. These studies make clear that hedonic pricing is useful for identifying features of a home's internal characteristics or external environment that can affect the home's selling price. The frequency with which residential or population density appear as control terms suggest it is one of these characteristics. These studies largely point to density having no strong effect on a home's selling price, but they also do not consider possible functional forms for the relationship.

Overall, previous hedonic pricing studies have found that increased housing or population density has a minor, mixed effect on home prices. In most studies, this effect was frequently within 0.1% of the home price, with the largest negative effect being the -0.86% change ($1,526 in dollar terms for the $177,461 average study home), in home price for each additional person per square mile found by Song and Knapp (2003) and the largest positive effect of 0.1% ($130 in dollar terms for the $129,610 average study home) change in home price for each additional house per acre found by Cho et al (2006). Given the findings of Dunse, et al (2013), this mixed effect is likely a result of these studies not fully incorporating the possibility that the density-home price relationship is not stable across different types of neighborhood and levels of density. If suburban locations do indeed consistently present convex quadratic relationships and urban locations present concave quadratic relationships, it would follow that hedonic pricing studies that did not account for these variations would find conflicting results for density. Care should be taken to ensure that findings for a geographic area do not aggregate two dissimilar areas.

DENSITY IN PLANNING LITERATURE

Planners often assume that density brings efficiencies in use of land and other resources, but that connection is not always well-defined or examined. For example, Groc (2007) notes that while many cities have related their sustainability goals to higher density, those cities do not make the connection explicit. Groc (2007) also introduces the concept of an “ecological footprint” – the amount of productive land required to maintain a city – by describing Vancouver’s planning attempt to reduce its ecological footprint to its physical footprint. in a discussion about “compact cities”, Gordon and Richardson (1997) challenge arguments from density proponents that more dense development can help save agricultural land and open spaces, reduce energy use, reduce congestion and travel times, and increase agglomeration benefits.

There is some discussion that consumer interest does not often consider density as an important factor, at least when compared to other features. Knack (2002) describes the connection between high-density locations and affluence as being driven by high demand for housing near urban amenities, cultural centers and activities, and social opportunities – urban features that are often sustained by high density, density. Gordon and Richardson (1997) note that many state and federal policies in the U.S. influence the housing market in such a way as to foster a preference for low-density development. Gordon and Vipond (2005) analyze areas of Ontario developed under New Urbanist plans with traditional suburban development and find the New Urbanist areas to be higher density with attractive streetscapes and no corresponding loss of parks space, among other features.

Much of the literature seems to be devoted to how to achieve higher-density development. Nelson (2006) argues that planners need to consider future demand in a context of increasing understanding of the public health concerns due to low-density development and the economic efficiency of high-density development. The article further develops templates for planners considering projects in central cities and outer suburbs. Burge, et al (2013) detail a method used by Albuquerque, New Mexico, to use zone-based impact fees to combat urban sprawl and promote more dense development.

Knack (2002) uses interviews with architects and planners to indicate how planners and designers can package and design dense developments with broad public appeal.

Findings in planning literature

While Gordon and Vipond (2005) and Gordon and Richardson (1997) admit to efficient land use provided by higher density and allude to a wider controversy about other efficiencies related to higher density development, the planning literature is largely settled on the pro-density side. Most articles seem to consider higher density as an assumed goal, with passing references to efficiency of land use, energy resources, transportation networks, and health initiatives that would result from higher density development. Authors seem to assume that readers already understand these benefits. Instead, planning journals and magazines focus on topics such as case studies of how individual cities have developed density-encouraging plans, used special zoning or fees to nudge developers towards higher-density projects, and designed higher-density projects to appeal to consumers.

Conclusion

Studies that individually found only minor effects of density upon home prices and in the aggregate found mixed effects likely suffered from two failures of analysis. The first failure of analysis was the assumption of a linear or logarithmic relationship between the two variables, which failed to account for the likelihood that this relationship is better described by a quadratic form. While the linear and logarithmic forms simplify descriptions of the relationship between the variables, both forms suggest that the relationship only changes in magnitude, not direction. This suggests that research into density should account for the possibility that the relationship is positive for one subset of the data and negative for the remainder. Given the findings of Dunse et al (2013), research into the relationship between density and home prices should account for a possibly quadratic relationship. It is important to note that in conditions where the inflection point of a quadratic relationship does not exist within the dataset, a linear or logarithmic relationship may be appropriate for analysis, therefore a reasonable check for use of a quadratic form is whether the inflection point is present within the dataset.

The second failure of analysis was an assumption that this relationship holds true across an entire study region, which failed to accommodate significant and variable effects of density on prices across geographically and demographically dissimilar areas. While reviewing aggregate data for an entire region, it may be reasonable to expect higher home prices in urban and rural areas than in suburban areas, the differences between these two locations may mask differences. For example, there may be features common to low-density neighborhoods that may reflect a convergence of homes on a minimum price at a certain density, or features common to high-density neighborhoods that may reflect a convergence of homes on a maximum price at a certain density.

Taken together, this suggests that my research should look for a quadratic relationship to ensure that any changes in magnitude and direction are identified and verify whether the inflection point for the analysis falls within the range of observations within the dataset. Further, I should review results for smaller subareas to identify whether those subareas share the same directions of relationships. It may be appropriate to draw conclusions for subareas with similarly-signed relationships, but it would not be appropriate to draw conclusion for subareas with different relationships. It follows that I should be wary of drawing a conclusion for an entire study area without analysis of smaller subareas. Any findings would help inform and extend the existing planning literature that already amply assumes and describes general social and economic benefits to increasing urban density.

3. QUANTITATIVE METHODOLOGY AND RESULTS

INTRODUCTION

This section describes the methodology used to develop my analysis. As indicated in the literature review, many types of input moderate home prices, including the desirability of the home itself, the desirability of the neighborhood it is in, and factors that affect the home sale itself. A hedonic price estimate feeds those inputs into a regression analysis to determine how much each characteristic contributes to a home's value. I describe how I collected the input data, the conceptual framework of my analysis, the dependent, explanatory, and other independent variables, the regression analysis itself, and finally, the results I found.

COLLECTING AND ANALYZING QUANTITATIVE DATA

My model adds explicit tests for whether the population density of the area around a home affects the sale price of that home, and if so, at what magnitude. As found in the literature, there are no consistent results for the effect density has on home prices, however colloquial real estate literature (Fontinellle, n.d; Pan, 2016) suggests that home buyers value homes in dense urban and sparse suburban or exurban areas. It would follow that middle-density suburbs would be less valued, *ceteris paribus*. I measure the influence of density (in thousands of persons per square mile) on home price in linear and quadratic terms.

Selling price	= ƒ	(Density measures, Property characteristics, Neighborhood characteristics, Sale characteristics)
Density measures	= ƒ	(Density of Census block group (persons per square mile) [in linear and quadratic forms])
Property characteristics	= ƒ	(Age of house, House size, Lot size, Bedrooms, One-story, Garage spaces, Fireplaces, Bathrooms, Pool, Siding type, Roof type, Sewer connection)
Neighborhood characteristics	= ƒ	(Median income, Race and ethnicity, Occupancy rates, Homeowners association, HOA dues, Special district assessments, ZIP code)
Sale characteristics	= ƒ	(Foreclosure, Month and year of sale, Days on market)

I collected data for this paper from two sources. First, home sales data from the Multiple Listing Service for Sacramento County from October 1, 2013 to December 31, 2013 and September 1, 2016 to December 31, 2016 was available for use by graduate students in the California State University, Sacramento Public Policy and Administration Program. This provided the property and sale data for 10,413 home sales during the periods studied. Neighborhood data came from the U.S. Census Bureau's decennial census and the 2015 edition of the American Community Survey. This involved geolocation of each home in the MLS data and retrieving the median income, racial and ethnic characteristics, and population density of its Census block group. Of the homes in the sales dataset, 10,130 were successfully geolocated and formed the dataset for this study. I chose block groups as the level of analysis because the average block group size in Sacramento County is 1.06 square miles, more closely matching the idea of a prospective homebuyer's "neighborhood" than the 3.04 square miles of a census tract or the 0.05 square miles of a census block. Analysis at the census block level was also complicated by sharp divergences of density levels between adjacent blocks, particularly when high density apartment buildings were situated next to single-family dwellings, despite being in the what most observers would consider the same neighborhood. Additionally, the Census Bureau’s American Community Survey data, while more frequently updated, only provides data at the block group or tract level.

This process yields a density curve for Sacramento County as a whole. However, it is possible that different geographic areas within the county may exhibit drastically different relationships between home prices and density. To test this, I repeat the above regression, with additional interactions between the density measures and ZIP code and report findings for areas that may show convex or concave quadratic relationships. In a convex relationship, home prices converge on a minimum value across the density range, while in a concave relationship, home prices converge on a maximum value across the density range. Additionally, I report the density of the geographic area and the difference between that value and the minimum or maximum. This indicates whether inicreases or decreases in density in the community would correspond to increases or decreases in home prices. ZIP codes were used as the level of analysis due to technical limitations preventing the use of smaller geographic areas, such as census tract or census block group.

Dependent variable

My dependent variable is the final selling price in 2016 US dollars of a home that sold in the final three months of 2013 or final four months of 2016. Using this common measurement allows a comparison across many possible factors that influence that home's price, such as the nature of the home itself, the community around it, the time of sale, and any other characteristics that would vary from home to home. 2013 data and 2016 data were tested separately and showed comparable results, suggesting compatibility for this analysis. I further delineated each year and month of sale through use of dummy variables, described below.

Independent variables

I divide my independent variables into three sets of characteristics around the nature of the home sold, the nature of the socioeconomic environment of the home, and the unusual circumstances surrounding the sale of the home in question. Table 2 follows this section and includes descriptions of each variable used along with the expected relationship of each variable to the final home selling price.

Property characteristics

These variables account for traits that are intrinsic to the home. Thus, property characteristics are those that contribute the value of the house to the overall sale price. Generally, I expect that increases in home size and amenities accompany increases in value.

Neighborhood characteristics

These variables represent the contribution of a home's value made by its immediate social and economic environment. Since the relative affluence of the neighborhood or predominance of a certain racial or ethnic group would matter to a homebuyer, it is captured in these variables. It is important to note that these characteristics are relatively independent of the homebuyer's specific preference for the amenities of the home itself. I expect that neighborhoods with higher socioeconomic status present higher home prices.

Sale characteristics

Sale characteristics are those that come into play based on the unique conditions of the sale of the house itself and have no impact on a homebuyer's preferences except to alter the price to make up for a more potentially challenging sale or to record the time between the home going on the market and completing its sale. A homebuyer finding the right home in the right neighborhood would do so with little concern as to how long it had been on the market, for example.

Density measures

These variables measure the effect density contributes to a home price. Density in this case is taken as population density of the Census block group a home occupies, measured by the number of persons in the block group divided by the land area of the block group. A typical rural area would have less than 200 persons per square mile and a typical urban area would have well over 10,000 persons per square mile. As mentioned above, previous studies have shown density to have a varying effect on home prices. Anecdotal factors also suggest that amenities related to both home buyers who seek higher and lower density areas. Therefore, I expect that homes see higher prices in the extreme ends of the density distribution and prices that dip lower for the middle range, in an inverse parabola.

Table 2: Descriptions of variables and expected relationships to selling price

Variable	Description	Expected relationship
Density Measures		
DensityGroup1000	Population density of the Census block group (1,000 persons per square mile), also as a squared term	quadratic
Property Characteristics		
Age	Age of house (years)	unknown
SquareFoot	House size (square feet)	positive
LotSizeSqFt	Lot size (square feet)	positive
Bedrooms	Number of bedrooms	positive
Dummy_SingleStory	Dummy variable for a one-story house (0=multi-story, 1=single)	negative
GarageSpaces	Number of car spaces available in garage	positive
Fireplaces	Number of fireplaces in the home	positive
BathFull	Number of full bathrooms in the home	positive
BathHalf	Number of half bathrooms in the home	positive
Dummy_Pool	Dummy variable for presence of a pool (0=no, 1=yes)	positive
Dummy_CentralHeat	Dummy variable for presence of a central HVAC system(0=no, 1=yes)	positive
Dummy_ExtX	Dummy variables for external siding type: brick, cement, lap, metal, mixed materials, shingle, stone, vinyl, or wood (Reference: shingle)	mixed
Dummy_RoofX	Dummy variables for roof material type: composite, metal, shake, slate, tile, or wood (Reference: metal)	mixed
Dummy_Sewer	Dummy variable for a connection to the sewer system (0=no, 1=yes)	positive
Neighborhood Characteristics		
Med_Income	Median income (dollars)	positive
Pct_White	Percentage of self-identified white population	positive
Pct_African	Percentage of self-identified African-American population	negative
Pct_Native	Percentage of self-identified Native American population	unknown
Pct_Asian	Percentage of self-identified Asian-American population	unknown
Pct_Pacific	Percentage of self-identified Pacific Islander population	unknown
Pct_Other	Percentage of self-identified “Other” ethnicity population (strongly correlates with Hispanic)	unknown

Variable	Description	Expected relationship
Pct_Mixed	Percentage of self-identified population of two more more races	unknown
Pct_Occupancy	Percentage of housing units occupied	positive
Dummy_HOA	Dummy variable for presence of a homeowner's association (0=no, 1=yes)	positive
HOADues	Amount of dues charged by the HOA	positive
Dummy_Assessments	Dummy variable for presence of a special district that charges additional assessments (0=no, 1=yes)	unknown
Dummy_TractX	Dummy variable for Census Tract (of 310 possible values, reference: 1200)	mixed
Sale Characteristics		
Dummy_Foreclosure	Dummy variable for whether the home was in foreclosure at time of sale (0=no, 1=yes)	negative
Dummy_ShortSale	Dummy variable for whether the sale was a short sale (0=no, 1=yes)	negative
Dummy_MonthX	Dummy variables for month of sale (of 7 possible values, reference: October, 2013)	unknown
DaysOnMkt	Number of days home was on market	negative

QUANTITATIVE DATA AND REGRESSION

This section describes the data used in the quantitative analysis and explains the variables in the regression, the functional form the regression takes, possible stumbling blocks with regression analysis, and presents the final findings of the regression.

Descriptions of variables

Table 3 presents the mean, standard deviation, minimum, and maximum for all the non-Census tract dummy variables used.

Table 3: Descriptive statistics of variables used

Variable	Mean	Std. Dev.	Min	Max
SellingPrice2016USD	317,305.2	157,476.7	28,331.22	2,900,000
DensityGroup[1]	5.986684	2.971795	0.0086772	23.62384
DensityGroup_Sq[1]	44.67107	40.87096	7.53E-05	558.0858
HomeSizeSqFt	1,692.213	666.7093	320	9213
LotSizeSqFt	132,415.5	6,538,368	0	482,000,000
Age	35.8522	22.55918	0	123
Bedrooms	3.310669	0.8032531	0	9
BathFull	2.02785	0.6367781	0	7
BathHalf	0.2141554	0.4153732	0	3
Dummy_SingleStory	0.7046961	0.4562012	0	1
GarageSpaces	1.867569	0.834705	0	10
Fireplaces	0.8425046	0.5468545	0	5
PoolDesc	0.1962931	0.3972119	0	1
CentralHeat	0.9420916	0.2335813	0	1
Dummy_ExtBrick	0.0060501	0.0775506	0	1
Dummy_ExtCement	0.0022088	0.046948	0	1
Dummy_ExtMetal	0.002881	0.0536003	0	1
Dummy_ExtLap	0.0466724	0.2109464	0	1
Dummy_ExtVinyl	0.0213195	0.1444541	0	1
Dummy_ExtShingle	0.0051858	0.0718292	0	1
Dummy_ExtStucco	0.4352252	0.4958103	0	1
Dummy_ExtStone	0.0018246	0.0426789	0	1
Dummy_ExtWood	0.1497167	0.3568106	0	1
Dummy_ExtOther	0.3289158	0.4698419	0	1
Dummy_RoofComposite	0.5949294	0.4909293	0	1
Dummy_RoofGravel	0.0011524	0.0339292	0	1
Dummy_RoofMetal	0.0083549	0.0910271	0	1
Dummy_RoofRock	0.0001921	0.0138582	0	1
Dummy_RoofShake	0.0307308	0.1725958	0	1
Dummy_RoofShingle	0.0107558	0.1031558	0	1
Dummy_RoofSlate	0.0013445	0.0366442	0	1
Dummy_RoofTile	0.3177759	0.4656342	0	1
Dummy_RoofOther	0.0347642	0.1831909	0	1
Dummy_Sewer	0.9648516	0.1841636	0	1
Dummy_HOA	0.1662345	0.3723089	0	1
HOADues	26.30875	95.99039	0	5,500
Dummy_Assessments	0.8504754	0.356622	0	1
Dummy_Foreclosure	0.0384135	0.1922016	0	1
Dummy_ShortSale	0.0606934	0.2387785	0	1

[1] Measured in thousands of persons per square mile.

Variable	Mean	Std. Dev.	Min	Max
Dummy_Sale201310	0.1480841	0.3552004	0	1
Dummy_Sale201311	0.1231153	0.3285853	0	1
Dummy_Sale201312	0.1358878	0.3426859	0	1
Dummy_Sale201609	0.1587439	0.3654546	0	1
Dummy_Sale201610	0.150485	0.3575633	0	1
Dummy_Sale201611	0.139345	0.3463229	0	1
Dummy_Sale201612	0.1443388	0.3514498	0	1
DaysOnMkt	80.19639	61.97623	0	919
Pct_White	60.39946	24.05713	0	100
Pct_Black	8.752856	9.570286	0	100
Pct_AmInd	0.9474496	1.832873	0	30
Pct_Asian	13.89509	14.04299	0	90.54054
Pct_PacIs	0.9021363	2.717405	0	100
Pct_Other	7.955076	9.165558	0	75.75758
Pct_Multi	6.498062	5.190955	0	100
MedIncome	66,885.77	28,147.18	11,863	186,875
Occupancy	94.30459	5.399263	68.39378	100

Regression results

Functional Form

Building on the model and data described in Section III, I run my regression analysis with one functional form: “Lin-Quad”, where the dependent variable is unchanged but the explanatory variable is converted into a quadratic form in order to identify possible changes in the otherwise linear relationship over the entire range of the data and where a quadratic relationship can be calculated to describe where the relationship changes from negative to positive. A large R-squared value indicates how well the regression analysis explains variation in the dependent variable around its mean. To address geographic similarities in the data not handled by the inclusion of tract dummy variables, I ran the regression with clustering on ZIP codes.

When using population or housing density as an explanatory variable in a regression analysis, other researchers used “Lin-Lin” and “Log-Lin” functional forms, representing fully linear relationships and logarithmic relationships, respectively. These forms provide more accessible interpretations of the results. In a Lin-Lin regression, unit increases in the explanatory variable correspond to unit increases in the dependent variable. In a Log-Lin regression, unit increases in the explanatory variable correspond to percentage increases in the dependent variable. However, both forms assume that relationships between the two variables are always positive or negative and would not identify the effect described in my hypothesis.

Heteroskedasticity and multicollinearity

Regression analyses can suffer from two problems within the underlying data: heteroskedasticity and multicollinearity. Heteroskedasticity is the inability of the regression to maintain constant variances across the entire range of data, leading data points at one end of the range to be less reliable than at the other. This biases standard errors upward and can make statistically significant results seem insignificant. I test for heteroskedasticity using the Breusch-Pagan test and when found, correct for it using robust standard errors. Results for the Breusch-Pagan test indicated P-values of 0.000, strongly suggesting the presence of heteroskedasticity. I therefore ran the regression with robust standard errors, in addition to the ZIP code clustering.

Multicollinearity is the presence of high correlations between ostensibly independent variables in the regression, leading to biased results. Two methods are available to identify multicollinearity: looking for variables with a correlation coefficient higher than 0.8 or calculating the variance inflation factor (VIF) for a regression, with VIFs of 5 or more suggesting that multicollinearity may negatively impact statistical significance. When multicollinearity is found, removing correlated variables can address it, although its presence does not preclude the regression analysis from continuing if the explanatory variable is not correlated.

A review of correlation coefficients among the variables other than the Census tract dummy variables indicated that the only very strong correlation coefficients are between DensityGroup1000 and DensityGroup1000_Sq (0.9431) and between Dummy_RoofTile and Dummy_RoofComposite (-0.8253). I found variance inflation factors above 5.0 only for statistically significant variables. These measures do not suggest that multicollinearity is a problem in my analysis.

RESULTS FOR ENTIRE COUNTY

Table 4 presents the regression results for this analysis for Sacramento County as a whole, with the 310 Census tract dummy variables included but not reported here. Asterisks indicate statistical significance, with one asterisk indicating a confidence level of 0.10, two asterisks indicating 0.05, and three asterisks indicating 0.01.

Table 4: Regression results for Sacramento County

SellingPrice2016USD	Coefficient	Robust standard error	95% confidence interval	
DensityGroup[2]	-4,210.439**	1891.644	-8008.073	-412.8059
DensityGroup_Sq	294.3136**	121.5268	50.33838	538.2888
Age	-170.0188	134.9978	-441.0382	101.0007
LotSizeSqFt	0.0000696***	0.0000176	0.0000341	0.000105
HomeSizeSqFt	143.0551***	14.53993	113.865	172.2453
Bedrooms	-10367.17***	3138.843	-16668.66	-4065.681
BathFull	17546.91***	4661.602	8188.35	26905.46
BathHalf	16936.27***	3746.044	9415.774	24456.77
Dummy_SingleStory	37966.08***	6220.168	25478.58	50453.59
GarageSpaces	12224.22***	1867.368	8475.324	15973.12
Fireplaces	10007.65**	4031.376	1914.329	18100.98
PoolDesc	12384.9***	2853.684	6655.888	18113.91
CentralHeat	11980.4***	2205.211	7553.259	16407.55
Dummy_ExtOther	-39666.34*	23435.15	-86714.37	7381.694
Dummy_ExtCement	-38508.74	24500.15	-87694.84	10677.37
Dummy_ExtMetal	-42648.3	25572.63	-93987.51	8690.906
Dummy_ExtLap	-40607.76*	21667.88	-84107.85	2892.321
Dummy_ExtVinyl	-41473.78*	22861.46	-87370.07	4422.503
Dummy_ExtShingle	-45770.02	28595.97	-103178.8	11638.78
Dummy_ExtStucco	-40105.08*	22928.73	-86136.42	5926.269
Dummy_ExtStone	-41284.38*	24443.45	-90356.67	7787.897
Dummy_ExtWood	-45380.45*	22836.88	-91227.41	466.5096
Dummy_RoofGravel	10011.61	18204.59	-26535.64	46558.86
Dummy_RoofMetal	1508.722	8921.7	-16402.34	19419.78
Dummy_RoofOther	8818.067*	4837.199	-893.0154	18529.15
Dummy_RoofRock	57832.15***	17721.83	22254.09	93410.2
Dummy_RoofShake	9953.761	8270.31	-6649.579	26557.1
Dummy_RoofShingle	-7793.295	11472.84	-30825.99	15239.4
Dummy_RoofSlate	9280.18	18126.93	-27111.16	45671.52
Dummy_RoofTile	2648.844	2548.887	-2468.26	7765.947
Dummy_Sewer	-33779.7***	8523.582	-50891.5	-16667.89
Dummy_HOA	-42341.7***	12384.93	-67205.49	-17477.92
HOADues	194.5802***	73.21777	47.58937	341.571
Dummy_Assessments	-348.1358	2163.149	-4690.838	3994.567
Dummy_Foreclosure	-42859.82***	4647.241	-52189.54	-33530.09
Dummy_ShortSale	-49339.41***	4344.152	-58060.66	-40618.16
Dummy_Sale201311	-146.7628	2529.537	-5225.02	4931.495
Dummy_Sale201312	871.8948	2819.581	-4788.65	6532.44
Dummy_Sale201609	55281.38***	2539.316	50183.49	60379.27
Dummy_Sale201610	60314.65***	2608.301	55078.27	65551.04
Dummy_Sale201611	56632.01***	2405.294	51803.18	61460.84

[2] Measured in thousands of persons per square mile.

SellingPrice2016USD	Coefficient	Robust standard error	95% confidence interval	
Dummy_Sale201612	58456.72***	2638.064	53160.58	63752.85
DaysOnMkt	12.20217	21.69379	-31.34992	55.75427
Pct_Black	-652.6803***	117.4704	-888.5119	-416.8487
Pct_AmInd	97.00626	387.5493	-681.0315	875.044
Pct_Asian	-449.7016***	77.54891	-605.3876	-294.0157
Pct_PacIs	272.0704	275.1953	-280.4071	824.5479
Pct_Other	-295.5434**	112.117	-520.6275	-70.45919
Pct_Multi	-515.7505***	163.4905	-843.9714	-187.5296
MedIncome	0.5412***	0.1176903	0.3049267	0.7774732
Occupancy	-40.15827	213.4688	-468.7148	388.3983

* denotes statistical significance to 0.1
** denotes statistical significance to 0.5
*** denotes statistical significance to 0.01

The regression results show that the key explanatory variable (population of Census block group) and that 35 of the other 50 non-Census tract explanatory variables have a statistically significant impact on the dependent variable at a 0.5 level or better. The regression resulted in an adjusted R-squared value of 85.3%, indicating a high level of explanation of the dependent variable. This means that the regression model can explain the variation of 85.3% of the dependent variable around its mean.

The quadratic relationship between density and home price makes it difficult to interpret how unit changes in density relate to changes in home prices. Instead, Figure 2 depicts a graph of predicted home prices across the density spectrum. The relationship shows that home prices are lowest for homes in Census block groups with 7,153 persons per square mile and rise steeply towards both lower and higher densities. Figure 3 depicts the block groups nearest this inflection point. These block groups tend to be scattered throughout the region. Homes in regions whose population density was within half a standard deviation of the inflection point tended to be older than the average home in the data set (40 years versus 36), with slightly smaller footprints (1,589 square feet versus 1,612), fewer garage spaces (1.79 versus 1.87) and pools (0.15 versus 0.20). These near-inflection homes were in block groups more likely to be non-white (57.5% versus 60.4%, with a 1.6 percentage point increase in African-American composition and a 1.1 percentage point increase in Asian-American composition) and have lower median incomes ($60,123 versus $66,886).

Figure 2: Predicted home prices at given density points in Sacramento County

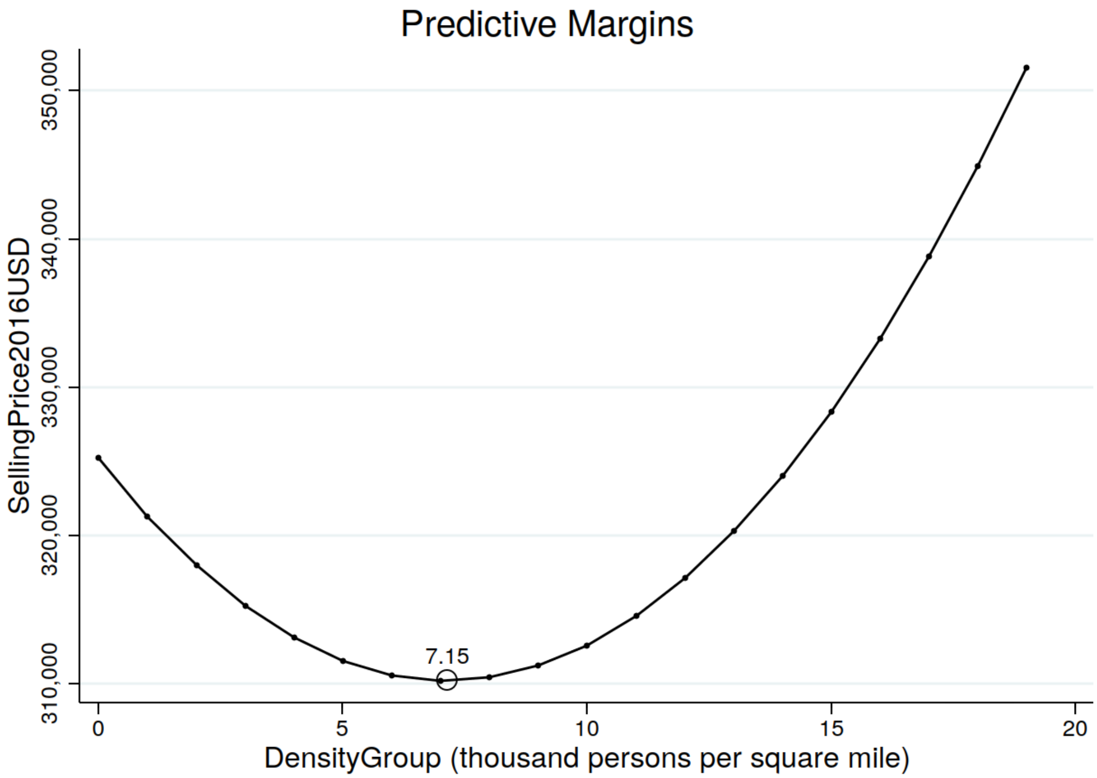
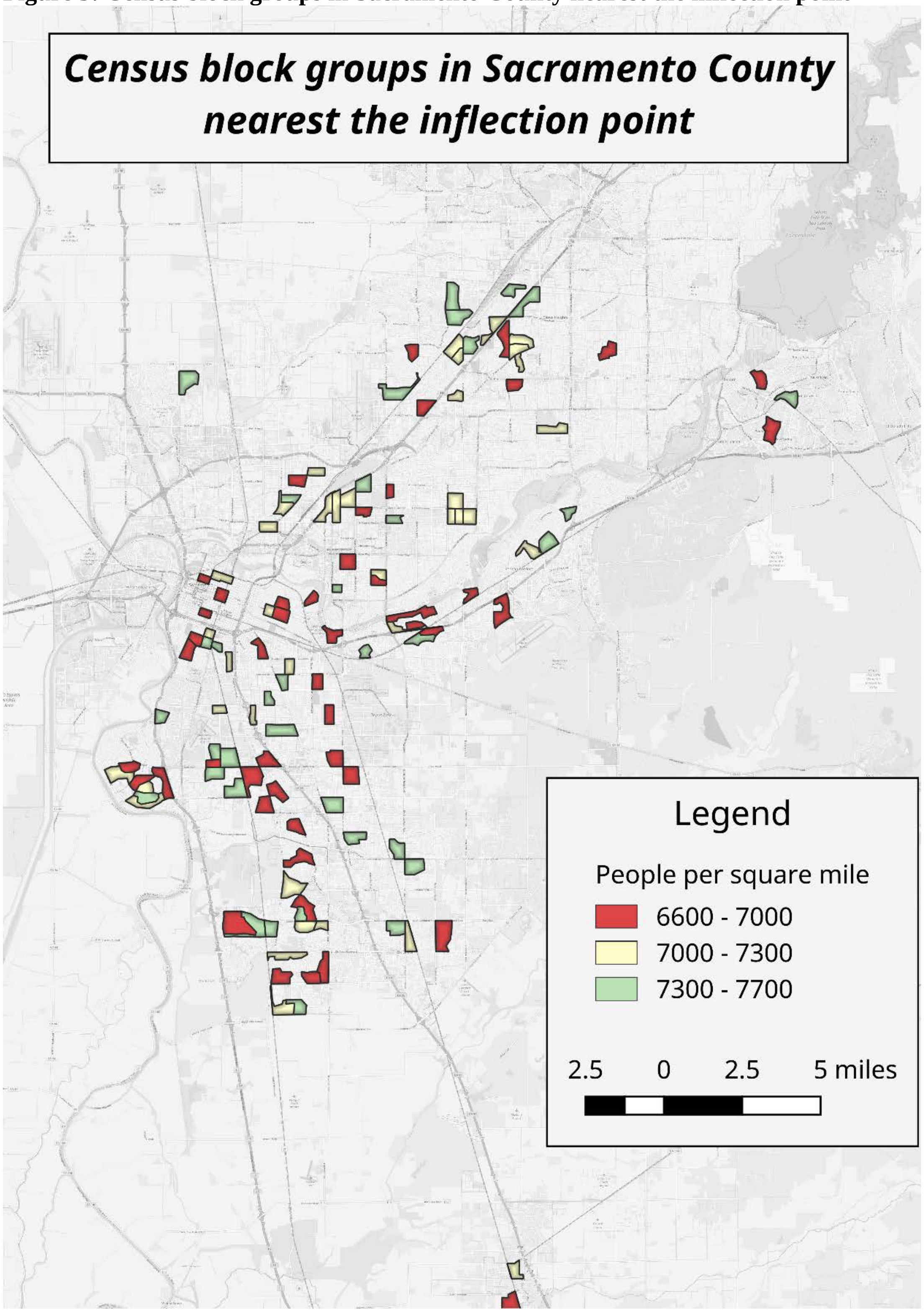


Figure 3: Census block groups in Sacramento County nearest the inflection point



RESULTS FOR ZIP CODE INTERACTION

Tables 5 and 6 present the regression results for this analysis for Sacramento County with the inclusion of the ZIP code interaction, again with the 310 Census tract dummy variables included but not reported here. Statistical significance is indicated with asterisks, with one asterisk indicating a confidence level of 0.10, two asterisks indicating 0.05, and three asterisks indicating 0.01. 53 total ZIP codes were present in the data.

I report results for the ZIP code interaction using convexity and concavity of the quadratic relationship. In a convex relationship, home prices converge on a minimum value across the entire range of density and increase as neighborhood densities move away from that minimum. This sort of relationship is depicted in Figure 2. In a concave relationship, the graph would appear inverted, with home prices converging on a maximum value across the density range and decrease as densities move away from that maximum. Figure 4 indicates whether a ZIP code had a concave or convex relationship. Table 5 presents the results for 24 ZIP codes with a concave relationship, and Table 6 presents the results for 18 ZIP codes with a convex relationship. Three ZIP codes had results that were not statistically significant and are omitted from analysis. Eight further ZIP codes were omitted from analysis due to excessive collinearity.

Figure 4: Quadratic relationships between home prices and population density for ZIP codes in Sacramento County

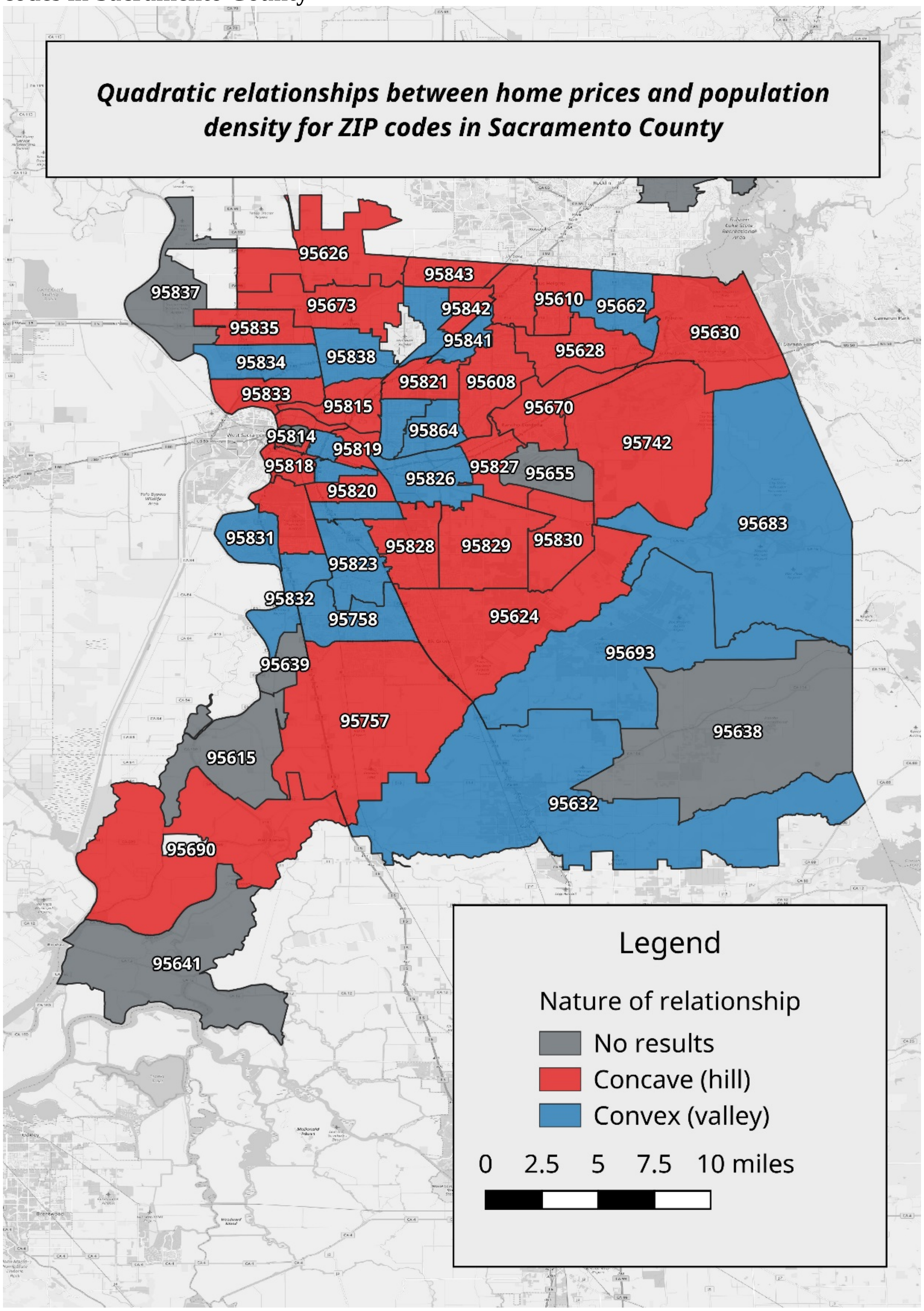


Table 5: Results for concave ZIP codes

ZIP Code	Density for maximum home price	Density observed	Difference	Median household income
95822	27.482	5.014	-22.468	$47,405
95815	9.407	3.145	-6.262	$29,870
95757	6.641	0.665	-5.976	$91,539
95821	10.008	4.691	-5.317	$39,588
95742	5.294	0.156	-5.139	$105,789
95670	9.354	4.220	-5.134	$56,527
95610	10.260	5.638	-4.622	$51,271
95829	5.485	1.191	-4.294	$80,118
95833	8.983	4.811	-4.172	$58,008
95624	5.372	1.409	-3.963	$84,854
95630	6.345	2.617	-3.729	$102,865
95608	7.816	4.556	-3.260	$56,891
95828	7.506	4.698	-2.808	$45,710
95811	4.553	2.727	-1.826	$38,538
95843	8.122	6.986	-1.136	$66,178
95842	9.250	8.122	-1.127	$44,462
95628	4.223	3.151	-1.072	$73,858
95626	0.896	0.257	-0.639	$56,667
95830	0.247	0.072	-0.175	$54,417
95690	0.067	0.044	-0.023	$53,493
95621	5.836	5.863	0.028	$52,462
95819	3.172	5.067	1.895	$96,633
95820	4.627	6.638	2.011	$42,948
95835	-3.942	4.012	7.954	$83,150

I found 24 ZIP codes to have concave relationships between home prices and population density. As shown on Figure 4, these ZIP codes were primarily in the central business district of Sacramento and a concentric ring approximately ten miles away that incorporates most of the suburban cities in the area, as well as some rural land to the extreme north of the county and in the predominantly agricultural Sacramento River Delta. Of these ZIP codes, 20 were less dense than the density associated with the highest home prices, indicating that increases in density would correspond to increases in home prices. Four ZIP codes were more dense than the density associated with a maximum home price, indicating that increases in density would correspond to decreases in home prices. In other words, the closer a ZIP code's density is to the maximum, the higher its home prices will be. However, one of these ZIP codes, 95835, recorded a negative maximum density and is likely an outlier. Excluding 95835, the average maximum density was 6,998 persons per square mile and the average observed density was 3,554 persons per square mile.

Table 6: Results for convex ZIP codes

ZIP code	Density for minimum home price	Density observed	Difference	Median household income
95824	27.332	7.442	-19.890	$29,747
95834	10.805	2.591	-8.213	$53,728
95758	12.785	4.712	-8.074	$74,164
95832	7.521	1.442	-6.079	$42,652
95826	8.534	3.179	-5.355	$55,772
95816	10.499	7.611	-2.888	$54,777
95831	8.334	5.914	-2.420	$68,140
95632	2.643	0.264	-2.379	$64,668
95838	6.309	4.054	-2.255	$40,815
95841	7.017	4.771	-2.245	$40,693
95662	4.597	2.903	-1.694	$72,134
95683	1.500	0.068	-1.432	$98,782
95693	0.148	0.108	-0.040	$85,417
95823	4.831	6.268	1.437	$39,294
95660	0.375	4.925	4.551	$39,677
95864	-3.239	3.499	6.739	$92,165
95825	-1.061	6.576	7.637	$36,647
95817	-36.020	5.907	41.928	$38,889

I found 18 ZIP codes to have convex relationships between home prices and population density. As shown on Figure 4, these ZIP codes were primarily located in two concentric rings, one approximately 5 miles from the central business district of the city of Sacramento, and another in mostly rural land 15 to 20 miles away from the central business district. Of these ZIP codes, 12 were less dense than the density associated with a minimum home price, indicating that increases in density would correspond to decreases in home prices and 6 were more dense than the density associated with a minimum home price, indicating that increases in density would correspond to increases in home prices. In other words, the further a ZIP code's density is from the minimum, regardless of the direction, the higher its home prices will be. For ZIP codes with observed densities below the minimum, the average minimum density was 8,310 persons per square mile and the average observed density was 3,467 persons per square mile. For ZIP codes with observed densities above the minimum, the average minimum density was -7,023 persons per square mile and the average observed density was 5,435 persons per square mile. The negative minimum density indicates that the relationship for these three ZIP codes may closely resemble a linear relationship, as the inflection point lies below zero persons per square mile, and that any increases in density will correspond to increases in selling price.

Median household incomes were overall higher in ZIP codes with concave relationships over those with convex relationships. The average concave ZIP code median income is $63,052, compared to the average convex ZIP code median income of $57,120. Of the 10 lowest median incomes, 7 were in the convex set and of the 10 highest median incomes, 7 were in the concave set. This suggests that there may be a connection between median income and population density. Such a connection is beyond the scope of this study and is a worthwhile subject for further research.

4. QUALITATIVE METHODOLOGY AND RESULTS

INTRODUCTION

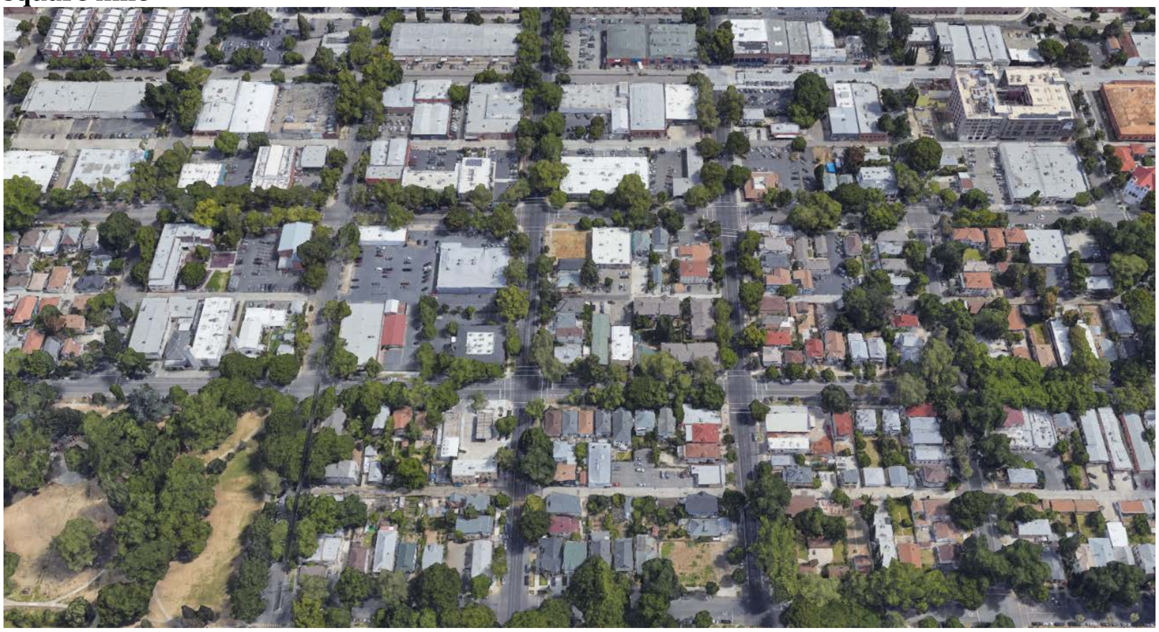
This section describes the methodology used to develop my analysis. As indicated in the literature review, the urban planning profession generally takes a stance in favor of increased density as a way to reduce greenhouse gas emissions and increase efficiency of land use, energy use, transportation networks, and other resources. As a result, the literature is devoted to discussions about methodology to set goals and develop tools to increase density in urbanized areas. I will describe interviews with three urban planners to identify whether current practitioners' views on density match the findings from the literature review as well as seek insight into methods used to achieve such development. I will also describe their impressions of the specific findings of my quantitative analysis. I will conclude by offering findings from those interviews.

CONDUCTING AND ANALYZING INTERVIEWS

My qualitative data consists of semi-structured interviews with three senior urban planners in public service positions. One planner works in the planning department for a medium-sized California city and was interviewed in person. Another works in the planning department for a California county and was interviewed over the phone. The third works primarily with housing in a Metropolitan Planning Organization in California and was interviewed in person. All were given informed consent letters (Appendix A) to inform them of their rights as interview subjects and a brief summary of the intent of this research to provide context for their participation. During each interview, I asked the subject questions from the interview question list (Appendix B). To ensure that the interview subjects were able to speak freely, their identities will remain confidential and they are described below simply as “city planner”, “county planner”, and “regional planner” as necessary. Upon conclusion of each interview, I transcribed each interview and divided the transcripts into individual comments. These comments were then coded based on their content into categories, with the comments from each category then compiled and reviewed to identify overarching themes and specific subjects for analysis and description. I used email to follow up for more information or to clarify statements.

Of note, the planners interviewed all used residential units per acre when describing density levels. This diverges from the general tendency of U.S.-based academic and research work to use persons per square mile as a measure. To help the reader understand the difference, Laidley (2016) and Guerra and Cervero (2011) identify density thresholds that can support the use of heavy passenger rail at 8,500 persons per square mile. This threshold corresponds to approximately 4.5 units per acre in the California jurisdictions represented by the interviewed planners. To a casual observer, 4.5 units per acre has the form of a typical mixed-use area incorporating closely-built single family homes, small apartment buildings, and small commercial and retail, as shown in Figure 5.

Figure 5: Area of Sacramento County with density of approximately 8,500 people per square mile



(Google, 2018)

DESCRIPTION OF INTERVIEW RESULTS

The coding analysis of the interviews yielded comments across six broad categories. The first category, “Effects of density”, identified the planners’ familiarity with the positive and negative effects of density on communities. The second category, “Personal and community preferences”, described the preferences that individuals exhibited towards or away from denser environments and development features that communities valued or disliked. The third category, “Planning methods and tools”, identified the tools used by the planners to make land use decisions. The fourth category, “Market conditions and obstacles to development”, described the conditions under which developments can go forward and what types of developments were more or less likely to come to fruition. The fifth category, “Recommendations”, compiled the planners’ suggestions on what areas were best suited for development, as well as what developments would be most beneficial to meet planning priorities. A sixth category, “Other issues”, collects other items of note.

Effects of density

Planners at all three levels stated that increased density brought net positive benefits to communities. They described numerous benefits, with all identifying increased density as a way to increase the utility of transit and opportunities to use other modes of transportation other than single-occupant vehicles. In particular, the regional planner noted that land use decisions and transportation opportunities had a bidirectional causal relationship, with higher density making buses more efficient to operate and more transportation options in turn making urban areas more desirable. All interview subjects also noted that increasing urban density would help achieve state goals, such as reducing greenhouse gas emissions and preserving the available open space and farmland around urbanized areas. Further, more dense development leads to more efficient provision of civic services and infrastructure, as potential developments can rely on existing utility lines and roads, though this often increases the strain on that infrastructure.

None of the interview subjects stated that increasing density would of itself increase housing affordability, although a planner at the county level noted that increases in housing costs are often offset by decreases in other costs of living. Similarly, the planner at the city level specifically noted that increased density is a contributor to a safer environment due to the inclusion of well-lit, active streets with many people around. This echoed comments by the other two planners that livability and place-making are high-priority goals of their work and of the planning profession, and that increasing density is a way to achieve that livability. One planner best described livability as a subjective measure, making an analogy to nutrition: just as people will enjoy a meal but not think about the different nutrients the food provides, people will enjoy the feel of a street or neighborhood but not necessarily think about the particular design or density of the neighborhood that contributes to that feeling.

Personal and community preferences

The three planners all elaborated on the importance of individual feelings and community sentiments about development density, with a focus on developing around livability and experiences over density. Planners at the city and county level noted a strong resistance in their jurisdictions to tall buildings and mismatches of scale, with some communities trying to erect jurisdictional barriers to increasing density through increases in height allowances. At the regional level, design was seen as more important than density in producing future developments that would have a positive feeling. However, the city planner noted that while dense areas tend to be more tolerant of increased density, areas with more single-family homes often balk at such increases. Those lower-density communities tend to be likely to resist future developments and increases in density, and community resistance has to be overcome with significant public outreach. Reflecting the planning literature, the planners painted a picture of communities in conflict between a desire for active, urban experiences nearby, but not so close as to change their immediate environment.

The planners did not agree on the experience and knowledge of population density exhibited by elected officials. All three planners agreed that elected officials represented their constituents' interests fairly well and balanced those interests against an understanding that higher density was something to welcome overall. Planners at the city and county levels felt that elected officials generally understood the effects of higher densities, though it can take a long time to develop a level of familiarity with the jargon and deeper effects. In contrast, the regional planner thought that elected officials were widely varied in their understanding, with leadership in some jurisdictions proving very savvy in high-density development that allows the jurisdiction to better capitalize on development potential. Meanwhile, officials in other jurisdictions display more limited knowledge and a greater willingness to put up roadblocks to higher-density development. The regional planner also noted that suburban jurisdictions in the region increasingly realize that they are running out of land and will need to shift to increasing development within their existing jurisdictions. This point is further emphasized by the county planner, who praised an urban growth boundary as a method for helping direct development attention inwards.

Planning methods and tools

The planners all discussed what methods and tools assist development efforts. Each utilized general plans, housing elements, and zoning to identify candidates for development. Getting these plans and zoning decisions right was difficult, as the county-level planner identified that planners could not assume that each parcel will be built out to its maximum allowed density and the city planner noted that current city zoning does not allow for some of the “missing middle” density that is currently seen in older, denser parts of the city. One older apartment building in particular was identified as having over 100 units per acre in a central-city neighborhood that was currently zoned for a “higher-density” maximum of 36 units per acre. Improvements of geographic information system technology made some elements of planning a simple computer-based exercise, making it easy to identify and rezone parcels. Local planners also used specific plans and corridors plans to further study smaller regions of a jurisdiction for appropriate development, impact fees to help fund necessary infrastructure improvements to support that development, and delegations of some design approvals to staff to help facilitate further development within their jurisdictions. While the local jurisdictions were mainly focused on questions of where specifically to put new development, the city and regional planner described pressure from the state to adhere to regional housing plans, with recent state legislation further increasing the carrots and sticks available to ensure that each jurisdiction took its allotted share of regional development.

Market conditions and obstacles to development

Beyond the impact of neighborhood sentiments and state requirements, all three planners identified market conditions and obstacles that affected approaches to development and increased densification. Each considered the housing market in covered jurisdictions to be skewed, with concern running high about the affordability of new housing stock and pricing-out of existing residents in high-density areas. While the county planner identified smaller variables like gas prices as a factor in settlement patterns, it was part of a larger set of deeper issues affecting development, such as the cost of construction and infrastructure needs at the city and regional levels. In particular, high construction costs were thought to be due to a tight labor market and saturation of contractor availability, leading contractors across Northern California to pursue opportunities in the highest-priced markets at the expense of other markets. This further constrains local infrastructure capacity, which needs further investment and increases the pressure on these jurisdictions to find contractors available to undertake such improvements. The city planner also noted that regardless of contractor availability, not every jurisdiction would have a market that will support the costs of constructing high-rise buildings.

While the regional planner noted a significant increase in interest in development within existing higher-density communities and a decrease in interest in developing in lower-density neighborhoods, this is tempered by difficulties in securing financing for infill projects. The county planner noted that this change is a change from a historical market interest in developing fringe areas and greenfields. As described by the city and regional planners, greenfield development is very well understood by banks and financiers, where existing financing plans can be taken and reshaped to fit the new project. In contrast, infill developments has to be carefully designed and financial plans tend to be single-use, requiring more involvement and analysis by the financing team. In addition, infill development often involves the demolition of existing structures, adding to costs, and does not benefit from the economies of scale involved with acquiring labor and materials for a large greenfield development. The county and regional planners also noted that all development suffers from difficulties in assembling parcels to build a coherent project.

Recommendations

All three planners shared opinions on where future development should be directed in order to maximize the benefits of density. This included suggestions to focus first on the urban core and downtown areas on the part of the city and regional planners, with the caveat that any new development needed a way to ensure that housing would remain affordable. The regional planner offered that urban areas and areas with high transit capacity should set targets of approximately 25 to 30 units per acre. This amount is well below the density identified by the city planner as currently in place in older, higher-density areas, where some longstanding buildings and projects may feature over 100 units per acre. Coming after the urban and transit-rich areas in priority, all three planners were in agreement that existing commercial corridors and older communities that have development capacity were high development priorities. The city and county planners recommended mixed-use developments with active ground floor uses in these areas to provide a community feel, with the county planner further recommending the use of master plans to better develop neighborhood concepts and mixed uses that could include parks, schools, and other uses than the typical residential and commercial uses.

Other issues

Two final concerns were identified by the city planner, who noted community involvement in zoning code changes and development planning processes. The observations were that density did not impact community perceptions as much as form did, but that communities are much more accepting of incremental changes over large-scale deviations from the current environment. Consequently, planners and developers should prioritize developments that fit within but push the boundaries of the scale of the community. In recent years, the city had “ratcheted up” its zoning code to require smaller setbacks, allow more and larger accessory dwelling units (also known as “granny flats”), and gradually increase maximum heights. Community and neighborhood groups had fought the initial changes, but were largely silent for the revisions, even when the revisions were more drastic than the original changes. Similarly, the jurisdiction’s experiences with controversial developments that took adversarial approaches to nearby communities and those that took collaborative approaches suggested that outreach was an important factor in determining whether a community was accepting of a development. altogether, the planner suggested that communities were most interested in maintaining continuity with their existing forms, and were willing to accommodate large changes over a period of time.

Review of quantitative findings

I presented the results of my quantitative analysis to the three planners. In the case of the county-wide finding of an overall convex relationship, the responses from planners were in line with my hypothesis. They described conditions where people seeking rural, lower-density areas were willing to pay a premium both in housing costs as well as in time and travel costs to employment or amenities in exchange for the “tranquility of not being near too many people”. As density increases, that isolation decreases but travel times and costs are still fairly high. This pushes demand and prices lower. Finally, as density increases significantly, urban experiences and human interaction become more valuable and travel costs and time decreases. This pushes demand higher and increases prices. This dipping of home prices near the middle densities explains the convexity of the findings.

The planners found the ZIP code-level results more difficult to explain. One planner was insufficiently familiar with the market and social demographic conditions to explain the findings. Another thought that ZIP codes were too coarse a geographic area to draw reasonable conclusions from, reflecting the rationale behind my use of census block group data in the initial regression. The third was able to formulate a hypothesis. This hypothesis noted that there are conundrums in the ZIP code data, where the same ZIP codes contain some of the county’s wealthiest properties as well as some of its largest low-income and immigrant neighborhoods. However, many of the ZIP codes that exhibit concave relationships are wealthier, containing high-performing high schools and exist on a corridor that would collect executive-level salaries between high-tech employment in Folsom, health facilities in the Arden-Arcade area, and professional jobs in downtown Sacramento. This contrasts with the areas with convex relationships, which have more working-class neighborhoods, greater distances to employment, higher immigrant populations, and fewer community gathering spaces. Overall, this hypothesis suggests that wealth and income are major determinants for whether a region would exhibit convex or concave relationships between density and home prices, but would require further testing.

CONCLUSION

The interviews with urban planners at the city, county, and regional levels provided a peek into the approaches used by professional planners. Interview questions probed whether they consider density in their work, how they do so, and what tools they use to influence land-use decisions that lead to greater or lesser density in a given area. All three subjects provided useful data on five of six categories identified in post-interview analysis of the interview transcripts and were mostly in agreement, with divergences of opinion possibly attributed to their separate vantage points based on the scale of geography and jurisdiction they operated within. The sixth category incorporated some views held by one planner that were not included in other categories.

The first category was the effects of density on communities. Interview subject responses reinforced the finding that the planning profession generally considers the question of whether increases in density bring benefits to communities largely settled in favor of increasing density. Justifications for this include acknowledgements that density reduces greenhouse gas emissions and contributes to other service and resource efficiencies. However, the subjects did note that density was not itself a goal, but that density increased features that make an area more livable.

The second category was personal and community preferences. Reinforcing some themes found in the first category, communities were described as not being aware of the effects of density directly, but were responsive to proposals to increase densities by increasing heights or building scales, though the communities were generally welcoming of active urban experiences. Elected officials were described as having mixed knowledge of the effects of density but were considered to do a good job of balancing constituent interests with good planning policies.

The third category was the planning methods and tools available to planners. This found that planners were able to describe computer-based, planning, and funding tools to help identify areas to develop and provide infrastructure to serve potential developments.

The fourth category was the market conditions and obstacles to development in each jurisdiction. Responses in this category discussed difficulty in developing affordable housing and in procuring construction materials and labor across a saturated Northern California construction market. Even absent the difficulty in construction, financing for the types of infill development that generally boosts density is much more difficult than financing for well-understood greenfield developments.

The fifth category was the recommendations each planner made about developing to increase density. All subjects agreed that downtown, urban core areas and transit-rich areas should be a priority for increased development, with commercial corridors in existing communities should follow, and that any such development should be mixed-use, including active ground-floor uses.

The final category was a discussion of how the city planner approached increases in density, favoring incrementalism and deep and sincere outreach with existing communities to help make zoning and planning changes more palatable to communities. Crucially, taking tentative first steps was a key to undertaking a radical revision of zoning and planning; once those steps were taken, subsequent changes could be more drastic but draw less confrontation from the community.

5. CONCLUSION

The purpose of this thesis is to identify if a non-linear correlation between population density and home prices exists, *ceteris paribus*. My mixed-method approach used a hedonic price estimate to test a quadratic relationship between the two variables. This approach also used interviews with urban planning practitioners to identify the current view of practicing urban planners on this subject and place the regression findings within the context of the urban planning field.

FINAL QUANTITATIVE RESULTS

The hedonic price estimate described in Chapter 3 utilized a dataset including over 10,000 home sales over seven months in Sacramento County, California. This data included numerous characteristics of the homes sold and neighborhood demographic information gleaned from the U.S. Census Bureau. This allowed me to control for a range of factors such as a home's size, construction, and amenities; the conditions under which it was sold; and neighborhood factors such as the median income, racial makeup, and occupancy of its census block group. The included variables explained up to 85% of the selling price of a home in the dataset.

My findings show that for Sacramento County as a whole, population density does have a quadratic relationship, with home prices trending higher in neighborhoods with very high densities and very low densities and decreasing as density approaches a middle range typified by a moderately dense suburban area. This convex quadratic relationship between density and home prices confirms the hypothesis stated in Chapter 1 and is in line with the planning literature. This relationship shows that increases in population density above the minimum in a neighborhood have a negative impact on home prices in that neighborhood until the neighborhood reaches 7,153 persons per square mile (approximately 3.75 housing units per acre). Census block groups in Sacramento County range between 8 and 33,222 persons per square mile, with an average population density of 6,052 persons per square mile, a median population density of 5,888 persons per square mile and a standard deviation of 3,448 persons per square mile. The 7,153 persons per square mile minimum point represents a value 0.37 standard deviations above the median population density, indicating that a significant number of neighborhoods in Sacramento County would see increases in home prices alongside increases in density.

The nature of the quadratic relationship only allows the prediction of the influence of a unit change of population density on home prices, if the starting population density is known. Since this density measurement is known for any neighborhood in Sacramento County, this regression result could be used to predict whether an increase in population density would increase or decrease the typical home price in a given neighborhood.

Further analysis that included interaction effects at the ZIP code level in the regression suggested that median incomes may have an effect on whether a density curve for a given block group is concave or convex, that effect may occur at smaller geographic areas, and that ZIP codes with lower median incomes tended to have convex relationships and ZIP codes with higher median incomes tended to have concave relationships. However, the ZIP code level tested is an inappropriately large geographic area from which to draw definitive conclusions. As mentioned in Chapter 3, the average Census tract in Sacramento County is over three square miles in area and does not conform to a "neighborhood" scale. The median ZIP code area is 9.3 square miles, further diverging from that neighborhood geography. This large size also causes ZIP codes to span geographic areas that contain very disparate communities. The ZIP code 95670, for example, contains a census block group that is 82% white with median incomes of $133,125 and another block group that is 46% white with median incomes of $31,477. To properly separate the effect of income on the direction of a quadratic relationship between population density and home prices would require smaller geographic areas that can address these disparities. Some ZIP codes in the interaction with lower overall median incomes

FINAL QUALITATIVE RESULTS

The interviews described in Chapter 4 polled three urban planning professionals at the city, county, and regional levels of jurisdiction within the Sacramento County region. Their responses were largely in line with the planning literature about the effects of increasing density. Increases in density were seen as positive for their ability to increase service and resource efficiencies and reduce greenhouse gas emissions. They also noted that communities often were not aware of the effects of population density changes and that elected officials tended to have a greater understanding of these effects but still faithfully represented their constituents' level of awareness. The planners also noted that future development and increases in density should focus on existing urban core areas and transit-rich corridors, though market conditions related to land and labor costs exacerbating difficulties in attracting funding for bespoke infill development plans.

The planners provided context for the county-level quantitative findings, explaining that home buyers seek the privacy and tranquility of low-density spaces, areas that demand higher prices due to lower demand and higher transportation costs due to their remoteness. Middle-density areas impose similar transportation costs due to sparsity of amenities but do not feature the tranquility and therefore feature low demand and low prices. As density increases into urban cores, civic amenities and experiences again increase demand, leading to higher prices. This explanation is largely in line with the planning literature.

The ZIP code-level income interaction, however, proved problematic for planners to describe, with one planner explicitly saying they didn’t like to use ZIP codes because they include too many diverse neighborhoods, as explained above.,

CONCLUSIONS

Planning literature suggests that increased density brings numerous benefits, including more cost-efficient public services, utility provision, transportation options, and improvements in greenhouse gas emissions and energy use per capita (Groc, 2007), and practicing planners agree with that literature. In as much as those increases in density occur in areas that are already well urbanized, my findings show that those improvements will also include increases in home prices.

From a policy standpoint, this acknowledgement of increased home prices linked to increases in density above the minimum has two effects. One is that higher-density development is indeed more highly valued by home buyers, indicating that it is a policy choice with public support in the abstract, notwithstanding activism directed against specific projects. The other effect is that increasing urban density will also increase the price of housing in that urban area, suggesting that those areas will see price increases that may drive out existing residents. Significant other research exists to address the NIMBY and gentrification effects of these increases in density.

Policy implications

These findings may be useful for municipal planning departments in deciding what densities to plan for. By identifying whether a neighborhood's density curve is convex or concave, planners can determine what the effect of increasing development can be and can tune their development plans for the greatest effect. For example, a planner seeking to significantly increase density without causing similarly significant increases in property values could prioritize development in an area that is already near and below the density minimum on a convex curve. Figure 3 depicts the Census block groups that are nearest the inflection point for the convex relationship for Sacramento County as a whole. For increases in density, block groups colored red would expect to have home prices decrease slightly, block groups colored yellow would expect little change in home prices, and block groups colored green would expect to have home prices increase. These findings would also be useful for developers seeking to maximize selling prices for homes in new developments or offer larger quantities of more affordable housing, using similar logic as that available to planners.

Geographically, most of Sacramento County has a density below the inflection point and would require significant increases of density in order to see increases in home prices. This includes the agricultural and rural southern and eastern portions of the county, as well as most of the suburban residential areas in Folsom, Carmichael, Orangevale, Fair Oaks, and Arden-Arcade. Some areas tend to have densities above the inflection point, indicating that increased development there would increase home prices. This includes areas such as midtown Sacramento, South Natomas, Antelope, and along the south Sacramento corridors of Highway 99, Center Parkway, and Stockton Boulevard. Some areas, like Rancho Cordova and Del Paso, tend to be mixed, with diverse density levels and therefore mixed reactions to increases in density.

Census block groups near the inflection point tend to be scattered throughout Sacramento County, defying easy classification. One cluster of groups occurs in northeastern Sacramento County in Citrus Heights near Interstate 80, with a number of block groups at or above the inflection point, indicating home prices would largely increase with further development. Another cluster is in the Pocket neighborhood, with the cluster consisting mostly of block groups at or below the inflection point, indicating that home prices would decrease or stay flat after density increases.

CONCERNS

Of primary importance to this paper, the literature review did not uncover any studies that looked at a possible quadratic relationship between population density and home prices. Nor did the literature review uncover much discussion of multicollinearity as a result of patterns of development. Homes in many neighborhoods share many characteristics, such as age of home, available amenities, construction material, lot and home size, and so on. While an older neighborhood may see some newer homes built as infill or replacement, newer communities are less likely to see variation among homes just by their relative youth. It may be appropriate to more carefully use both location-based and amenity-based variables in hedonic studies.

Further, endogeneity is a concern with this data, particularly when it comes to socioeconomic factors. Endogeneity is best described as a confused causal relationship, and in this case may be present in the data a few ways. For example, low neighborhood incomes may contribute to low home prices, as limited resources make it difficult to maintain a home and neighborhood in a way that is attractive to more affluent buyers. Alternatively, economically disadvantaged people find themselves with limited options to buy a home, and can only afford to live where prices are low. Low neighborhood incomes may drive low home prices, or the low home prices may drive the neighborhood to host low-income earners.

OPPORTUNITIES FOR FURTHER RESEARCH

This research does not identify potential causes for why home prices vary as they do depending on neighborhood population density. It speculate that specific amenities or characteristics such as increased retail density or local walkability may drive higher prices as population density increases or that a high preference for personal space or available land may lead to higher prices for specifically lower densities. Such research could help settle the score between the neighborhood activists fighting to maintain the current density levels and the urban planners seeking to increase density and provide a range of expectations for policymakers to consider when developing housing policy.

Additionally, the ZIP code interaction suggests that the quadratic relationship between density and home prices is not replicated across subgeographies of Sacramento

County and actually inverts itself in some areas. This change seems to be linked to median income. Further research could investigate whether there is indeed a relationship between income and the density curve. Such research should choose a more appropriate level of analysis than the fairly coarse ZIP code level.

APPENDIX A

INFORMED CONSENT FORM

Effects of Population Density on Home Prices

My name is Ryan Sharpe, and I am a graduate student at California State University, Sacramento, in Urban Land Development. I am conducting this research study to identify the relationship, if any, between population density and home prices in Sacramento County. If you volunteer to participate, you will be asked to sit down for an interview with me. Your participation in this study will involve one interview session between 30 and 60 minutes in duration.

Your participation in this study is voluntary. You have the right not to participate at all or to leave the study at any time without penalty or loss of benefits to which you are otherwise entitled. There are some possible risks involved for participants. These risks are not anticipated to be any greater than risks you encounter in daily life. There are some benefits to this research, particularly better housing policy through more direct knowledge of the relationship between density and home prices.

Option #1 Collecting individually identifiable information: It is anticipated that study results will be shared with the public through presentations and/or publications. Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission. Measures to insure your confidentiality are encryption and password protection of my files related to the interview and subjects. Raw data containing information that can be identified with you will be destroyed after a period of 3 years after study completion. The de-identified data will be maintained in a safe, locked location and may be used for future research studies or distributed to another investigator for future research studies without additional informed consent from you. Raw data will be destroyed after a period of 3 years after study completion.

If you have any questions about the research at any time, please contact me at ryansharpe@csus.edu or 916-xxx-xxxx, or my advisor, Rob Wassmer at rwassme@csus.edu 916-278-6304. If you have any questions about your rights as a participant in a research project please call the Office of Research, Innovation, and Economic Development, California State University, Sacramento, 916-278-5674, or email irb@csus.edu.

Your participation indicates that you have read and understand the information provided above, that you willingly agree to participate, that you may withdraw your consent at any time and discontinue participation at any time without penalty or loss of benefits to which you are otherwise entitled.

Please keep this form as your copy.

APPENDIX B

Interview questions

Does population density play in your work or the planning profession at large? If so, what is that role?

Do you see increasing population density as a goal -- direct or indirect -- of your planning work?

What do you see as the effects of planned changes in population density? Do these effects tend to be net positive or negative?

What methods are available to you to plan for higher or lower densities in planning at project or regional levels?

What barriers exist to enacting and implementing plans with desirable population densities?

Can you describe an idealized mix of densities in a project or region?

What sorts of developments do you find interesting? Would you consider them to be high or low density?

In your experience, does the public have accurate knowledge of the effects of increasing or decreasing density?

In your experience, do elected officials or other decision-makers have accurate knowledge of the effects of increasing or decreasing density? Do their decisions consider density explicitly or implicitly?

Are there areas of Sacramento County that could benefit from changes in density? Are there areas that would be hurt by changes in density?

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