URBAN FORM AND HOME VALUE: A HEDONIC ANALYSIS IN SACRAMENTO, CALIFORNIA

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URBAN FORM AND HOME VALUE: A HEDONIC ANALYSIS IN SACRAMENTO, CALIFORNIA

A Thesis

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Abstract

of

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Statement of Problem

This thesis attempts to discover through hedonic price theory whether urban form (especially as characterized as desirable by the New Urbanism movement) is valuable to homebuyers in the city of Sacramento. If so, homebuyers will pay a premium for homes in neighborhoods that exhibit urban form qualities closely resembling those of New Urbanist neighborhoods.

Sources of Data

Sample data for the City of Sacramento is from four sources: 1) Housing related data was obtained from Multiple Listing Service (MLS) for the Sacramento six county regions. 2) Demographic, economic, and educational data for the City of Sacramento is from the 2000 U.S. Census SF3 data tables. 3) Spatial data related to land use, streets, parks, parcels, major roads, highways, light rail, and intersections, is from the City of Sacramento Community Development Department.

Conclusions Reached

This study confirms the findings by other researchers that urban form affects home value, all else being equal. The findings reveal that homes located in neighborhoods with a New

Urbanist-style urban form sell for a 4.25% premium compared to homes located in a typical suburban neighborhood. Furthermore, this indicates, based on the sample data, that there is a measurable preference for a New Urbanist-style urban form.

_______________________, Committee Chair

Robert W. Wassmer, Ph.D.

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Date

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INTRODUCTION

Purpose of Study

This thesis attempts to discover through hedonic price theory whether urban form (especially as characterized as desirable by the New Urbanism movement) is valuable to homebuyers. If so, homebuyers will pay a premium for homes in neighborhoods that exhibit urban form qualities closely resembling those of traditional neighborhoods. Demonstrating the effect that urban form has on home value (if any) will provide beneficial information to New Urbanist developers, city planners, homeowners, and future homebuyers.

To provide context for the analysis of this study, the rest of this chapter introduces some of the future challenges for urban land development in California. First will be a discussion of the role New Urbanism plays in urban land development, followed by a discussion of the benefits and costs associated with suburban development,[1] then a discussion of the neighborhood qualities that New Urbanists claim people value, and finally, a discussion of hedonic price theory and its application to this study.

California Growth Machine

California has experienced rapid urban growth over the past decade. Suburban development, the expansion of roads and freeways, and even the formation of new cities have driven the economic machine throughout California. However, all this growth came to a stop in 2007, when the housing market crashed and the state, along with the nation, entered an economic recession.[2] Since then, California has experienced record unemployment, a deepening state budget crisis, and one of the highest real estate foreclosure rates in the nation.

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[1] Development refers to any new growth in the form of housing or commercial construction.
[2] According to data from Zillow.com, home values in the city of Sacramento began to decline in 2005.

Although the recent economic recession has significantly slowed urban growth, development in California continues. California's population has grown nine percent over the last decade, from 33 million people in 2000 to more than 36 million people in 2009, and it is expected to increase to over 49 million people by 2025 (Campbell, 1996). So what does all this mean for urban land development in California? First, new housing and jobs will be required to accommodate future population growth. Second, development will require new and updated infrastructure (roads, sewer, water, communication, and mass transportation). Moreover, changing demographics and dwindling resources will influence future urban land development patterns.

Growing Pains

Changing economic, racial, and generational demographic patterns are currently influencing preferences for housing and will continue to do so in the next decade. Aging baby-boomers and young single professionals—a burgeoning demographic— are two segments of the population that are showing a shift in housing preference for smaller living spaces and walkable neighborhoods (Leinberger, 2008). In addition to the generational demographic changes, there is evidence from a Brookings Institute report, *The State of Metropolitan America,* that there is a major shift occurring in the economic and racial makeup of suburbs nationwide (Berube, et al., 2010). The suburbs today have greater numbers of minority and low-income populations than they did ten years ago. The report also found that although whites still make up the majority of suburban populations, younger educated professionals are seeking more urban lifestyles.

Transportation costs and energy prices will also influence housing preferences in the next decade. Currently the United States is heavily dependent on fossil fuels to power and propel the economy and society in general. Many petroleum experts predict worldwide oil supply to peak within the next two decades. Oil is the most crucial resource that our society relies upon to fuel the economy. As long as demand remains unchanged, any reduction in production capacity of oil will lead to higher energy prices. The U.S. military (the largest government user of oil in the United States) in a 2010 report raised concern over future production capacity and dwindling supplies worldwide (Macalister, 2010). Other countries are worried, as well. Australian city planners are so concerned with the impact that rising energy prices will have on the suburban communities throughout Australia that these planners are in the process of reevaluating the country's growth strategy.[3] Peter Newman, Professor of Sustainability at Curtin University and an expert on automobile dependence, predicts that as oil prices increase and automobile transportation becomes more expensive, "suburbs that are car-dependent … will become the slums of the future" (West, 2010). Higher oil prices will increase household transportation costs and energy costs. As these costs begin to represent a greater percentage of overall household expenditures, household preferences will shift away from suburban development toward development with lower transportation costs.

Urban land development paradigm shift

Evidence suggests that urban land development is undergoing a paradigm shift. Changing consumer preferences, natural resource constraints, and concern over increasing environmental and social costs of suburban development is leading city planners and consumers to rethink the value of the suburban development model. New Urbanism is just one of the emerging development alternatives for which there is a growing demand (Leinberger, 2008). The goal of New Urbanism is to reshape public policy, development practices, urban planning, and design, in an effort to promote diverse pedestrian and transit-oriented, walkable, mixed-use development at the regional, city, and neighborhood level (Congress of the New Urbanism, 2001). The New Urbanism movement is attempting to shift growth away from suburban development patterns to

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[3] Growth patterns in Australia are similar to patterns found in the United States.

that of a pattern that is more in line with changing demographic trends, natural resource constraints, and environmental and social issues.

In the book, *The Option for Urbanism,* Leinberger (2008) analyzed the price premium and demand for walkable development. He concludes that homes in walkable neighborhoods command a significant price premium when compared to similar homes in suburban neighborhoods. He also finds that there is a significant demand for an alternative to standard suburban development and that price premiums will continue to increase, as the real estate sector is slow to meet increasing demand for compact development.

Suburban development

Various social, economic, and political forces have driven the evolution of suburban development for the past seven decades. Increased demand for housing, the construction of the interstate highway system, and racial issues are a few of the major forces that led to the suburbanization of the U.S. In 1945, the end of World War II led to the return of tens of thousands of troops to the U.S. from abroad, who were looking to settle down and start a family. What followed was a huge housing and population boom. To meet the new demand for housing, homebuilders like William Levitt built large planned communities at the edge of urbanized areas. Levittown, New York, built by Levitt and completed in 1948, is one of the earliest examples of suburban development.

New government policies and massive expansion of infrastructure further drove the suburbanization of the U.S. The federal government, in 1944, initiated the federal mortgage loan program, which assisted veterans with home loans. Between 1940 and 1950, the homeownership rate in the U.S. increased by 26% (U.S. Census Bureau, 2004). Additionally, in 1947, the U.S. entered the Cold War era. During this time, the interstate highway system was rapidly expanded to facilitate the movement of military equipment and personnel. Also during the 1950s, the country was still struggling with racial issues. New freeways and continued racial conflict nationwide facilitated the migration of whites to the suburbs. Known as “white flight,” this syndrome led to the urban decay of the majority of cities nationwide. Today’s suburban development is the direct result of various social, political, and historical forces, which have shaped it over the past 60 years.

Benefits and costs of Suburban Development

Suburban development, along with its iconic detached single-family home situated on a large lot, has been synonymous with the “American dream” for more than six decades. Lower housing prices, greater consumer choice, and greater participation in local government are some of the benefits that suburban development provides to both the individual and society. In general, land price decreases as the distance from the urban core increases (Alonso, 1964). Lower land prices allow for larger lots, and typically, larger homes for lower prices compared to homes located closer to the urban core. Larger lots also mean lower-density neighborhoods, which families with children generally prefer to higher-density neighborhoods.

The growth of suburban development over the past decades has led to the formation of new municipalities e.g. Elk Grove, California. The formation of new municipalities is beneficial to households for two reasons. First, this essentially gives households a choice in what level of public goods they prefer because different municipalities provide varying levels of public goods and government services / regulations e.g. tax rates, number of schools etc. This idea is based on the Tiebout theory of voting with ones feet (O’Sullivan, 2009). In other words, households move to municipalities that provide them with an ideal level of public goods and government services or regulations. Because of the Tiebout process, municipalities over time become sorted socially and homogenous (O’Sullivan, 2009). Secondly, more municipalities mean that size of local governments is smaller. Smaller local governments mean that households have greater representation as a percentage of the local government (O'Sullivan, 2009). This promotes stronger citizen participation in local government issues. In general, households have a greater say in government decisions that affect their home value and community and more choice in the level of public services demanded.

Criticism of Suburban Development

While the benefits of suburban development to the individual household do warrant some merit, the costs to society however far outweigh the benefits of suburban development. Suburban development generates negative externalities, which impose higher costs on society. Negative externalities are the result of an action by an individual, which imposes an external cost on society. For example, suburban development generates excess pollution, traffic congestion, infrastructure costs, and healthcare costs, which are not fully internalized in the cost of the action, which created it. These negative externalities are the result of the physical design of suburban development. Additionally, the suburban pattern coupled with the economic growth and prosperity of the United States over the last five decades, has exacerbated the negative effects of suburban development.

Single land-use, low-density development, and auto oriented circulation patterns are the three most predominant physical design characteristics of suburban development (Calthorpe, 1993). First, suburban development typically has highly segregated land uses. For example, residential uses and commercial uses are separate. Secondly, suburban development is typically comprised of low-density single-family residential homes and low-density commercial services, such as strip-malls and big-box stores. Finally, street network patterns in the suburbs utilize curvilinear roads and cul-de-sacs rather than a grid-like street network pattern. The suburban street pattern and lack of connections within and between separate land uses create an auto-oriented environment.

Over the last fifty years, the unprecedented economic growth in the United States has allowed Americans to demand larger homes, consume more energy per household and consume more cars. For example, median home size, household energy consumption, and the number of registered cars nationwide all have increased. Median home size in the US has increased 40% from 1,500 square feet in 1973 to 2,100 square feet in 2009 (U.S. Census Bureau, 2009). Suburban households on average use 27% more energy than urban homes (U.S. Energy Information Administration, 2005). The total number of registered cars has doubled between 1970 and 2008 (U.S Department of Transportation, 2010). The physical design of suburban development and the country's economic growth contributes to much of the criticism surrounding suburban development.

Critics argue that the design of suburban development creates numerous negative side effects, such as automobile dependency, high infrastructure costs, noncontiguous development, lack of reliable transit services, and more traffic and congestion on roads and highways (Calthorpe, 1993; Duany, 2000). Others argue the suburban pattern of development contributes to air and water pollution and the loss of open space (Meredith, 2003). From a social point of view, suburban development contributes to racial segregation, the concentration of poverty, and the spatial mismatch of home and place of employment (Meredith, 2003). Finally, from a health point of view, reduced physical activity due to more trips taken by car than by foot or bicycle can lead to conditions such as obesity, hypertension, and diabetes (Frumkin, Frank, & Jackson, 2004). Additionally as people spend more time in traffic and on congested roads, stress levels tend to rise, leading to increases in blood pressure, negative moods, anger, and road rage (Frumkin, Frank, & Jackson, 2004).

What Do New Urbanists Think that People Value?

New Urbanists posit that homebuyers value an urban form that is compact and mixed-use rather than sparse and segregated (Brown & Cropper 2001). Compact urban form can facilitate greater accessibility and walkability within and throughout a neighborhood; it allows for a mix of residential and commercial uses, public spaces, and open spaces within walking distance of each other. Compact form also allows for greater transportation options (e.g. bus, light rail, cycling, walking). Second, New Urbanists assert that homebuyers today value housing that has traditional architecture rather than typical suburban architecture (Duany, Plater-Zyberk, & Speck, 2000). Specific architectural elements include usable front porches, durable materials, setback garages (often detached from house), picket fences, variation in building facades, and massing of structures. Finally, New Urbanists claim homebuyer's value neighborhoods with a variety of housing types, a sense of place and community, safety, a healthy environment, and social diversity (Calthorpe, 1993).

Hedonic price theory and how it can be used?

If New Urbanist claims are true, then the value of urban form is capitalized into the price of housing (in the form of higher price units). This study uses hedonic price theory to estimate the value and demand for urban form characteristics. The hedonic price model is a well-developed econometric tool that measures the effect on price of specific characteristics or qualities of a heterogeneous product. Numerous academic studies have made use of hedonic price theory to analyze the effect that numerous structural, environmental, racial, and geographical characteristics have on home value. Hedonic price theory is based on the notion that heterogeneous products are comprised of a bundle of characteristics. For instance, the characteristics that make up housing might include the structure, the land, and the neighborhood where the home is located.

Products like housing have an explicit price and housing transactions take place in traditional markets. The individual characteristics of a home, however, do not have an explicit price and are not bought and sold in traditional markets. The housing structure, the land that the home is on, and the neighborhood context where the home is situated, for example represent broad characteristics that affect home value. These broad characteristics can be broken down into numerous specific characteristics. Hedonic theory uses regression analysis to estimate the implicit value or demand for each individual characteristic. This allows researchers to tease out very specific characteristics of housing which might have a significant effect on home value.

Chapter Summary

Urban growth in California is going to continue in the coming decades. However, the next two decades of growth will not resemble that of the past six decades, because changing demographic trends and resource constraints are two factors that will significantly influence urban land development in California in the near future. For the past 60 years, suburban development has been the pattern of choice for both developers and homebuyers, proliferating nationwide, and driven by demand for detached single-family homes on large lots coupled with cheap oil prices. While suburban development does provide some benefit to the individual, it incurs even greater costs on society. Planners, architects, and environmentalists have been raising concerns about this issue for more than 20 years. Opponents of suburban development have long advocated for a different pattern of growth, one that is compact, mixed-use, and pedestrian- and transit-oriented. New Urbanism is one such pattern that is gaining the attention of city planners and developers as an alternative to suburban development.

What is to follow?

Using hedonic price theory, this study attempts to estimate the value and demand for the urban form characteristics that resemble New Urbanism. Urban form is disaggregated into various observable characteristics, such as street pattern and distance to services. Variables that quantify the observable characteristics are created using geographic information systems (GIS). Past empirical studies have found that neighborhood characteristics, in addition to structural characteristics, influence home value (Song & Knapp, 2003). Therefore, to isolate the effects that urban form characteristics have on home values, the analysis will include a set of housing and neighborhood characteristics to control for variation in home value. Regression analysis is used to estimate the implicit value of each characteristic.

This study consists of five chapters, which provide a detailed analysis of urban form and home values in the city of Sacramento. Chapter 2 provides a discussion of past empirical research related to New Urbanism, urban form, and housing. Chapter 3 provides a broad overview of the methods used to measure the effect of urban form on housing prices. Chapter 4 provides a discussion of the results from the hedonic model. Finally, Chapter 5 concludes with a detailed discussion of how the findings apply to urban land development.

Chapter 2

LITERATURE REVIEW

Introduction

This chapter provides a review of relevant literature on topics related to New Urbanism, urban form characteristics, housing characteristics, and neighborhood characteristics. The characteristics of New Urbanism, housing, and neighborhoods are further explored to determine quantifiable variables, which proxy for each category. Further discussion focuses on past research using hedonic regression to measure the effect that urban form characteristics, housing characteristics, and neighborhood characteristics have on home values. In addition, the challenge of analyzing spatial data and accounting for various spatial effects is explored. Finally, there is a discussion of how this background information applies to this thesis.

Observable Characteristics of Traditional/New Urbanist Neighborhoods

According to the *Charter of the New Urbanism,* "… neighborhoods should be diverse in use and population; communities should be designed for the pedestrian and transit as well as the car; cities and towns should be shaped by physically defined and universally accessible public spaces and community institutions; urban places should be framed by architecture and landscape design that celebrate local history, climate, ecology, and building practice" (Congress of the New Urbanism, 2001). New Urbanism borrows much of its design philosophy from pre-World War II traditional neighborhoods (Calthorpe, 1993).

The Congress of the New Urbanism's (CNU) broad definition of New Urbanism, however, sheds little light on specific observable characteristics of New Urbanism. Others define New Urbanism in terms of density, mixed land use, and pedestrian orientation (Brown and Cropper, 2001). Furthermore, an empirical study by Song and Knapp (2003) divides the characteristics of New Urbanism into six categories of quantifiable variables: street design and circulation system, density, land-use mix, accessibility, transportation mode choice, and pedestrian walkability. These six categories proxy for urban form and provide a structure for the review of literature.

Measuring Urban Form Characteristics Using the Hedonic Price Model

The impact of urban form (as a whole) on home values has not been widely studied by academics. Perhaps one reason for this is that there is no concise definition of urban form. The majority of studies reviewed analyze a single individual characteristic of urban form on home value rather than urban form as a whole. For example, Guttery (2002) analyzed the effect of alleyways on home values in Texas. Cao and Cory (1981) analyzed the effect of mix land-uses on home values in Tucson, Arizona.

According to Song and Knapp (2003), street design and circulation system, density, land-use mix, accessibility, transportation mode choice, and pedestrian walkability best define New Urbanism. Fifteen empirical studies are reviewed which have analyzed the effect on home value of at least one of these six broad characteristics. Table A1 in the appendix provides a summary of the empirical studies, the variables used, the significance of the results, and the magnitude that each variable has on home value. What follows next is a discussion of the direction of effects of various urban form characteristics found to be statistically significant. Please refer to the table A1 for details on the magnitude of these effects.

Street pattern

The effect of street pattern on home value has not been widely studied using hedonic regression. Perhaps one reason for this is that there is no concise definition of street pattern. Song and Knapp (2003) analyzed the effect of street pattern and circulation systems on home values in Washington County, Oregon. They found that greater internal connectivity of neighborhoods, number of streets, and the number of blocks, significantly increase home value. Matthews and Turnbull (2007) found that greater integration in grid-like street patterns, like those found in New

Urbanist and traditional neighborhoods, significantly increase home value. These findings agree with the assertion by New Urbanists that people value highly connected (grid-like), pedestrian-scaled, safe street patterns.

Other studies use cul-de-sacs to proxy for street connectivity. Cul-de-sacs reduce street connectivity by creating dead-end streets. Song and Knapp (2003) found that homes located within 50 feet of a cul-de-sac sold at a premium. Asabere (1990) found a similar positive effect of cul-de-sacs and home values in Nova Scotia. The positive effect of cul-de-sacs found by both studies, while, contrary to the New Urbanist claim that people value connected street patterns rather than disconnected street patterns, is likely due to the beneficial effects of less through traffic and less noise.

Alleyways are another component of street pattern. New Urbanists claim that alleyways increase neighborhood connectivity and eliminate the visual prominence of garages.[4] Guttery (2002) analyzed the impact of alleyways on home value in Dallas and found that homes located on alleyways sell for a significant discount compared to homes not located on alleyways. Guttery (2002) argues this is evidence that the negative externalities (e.g. crime, appearance, noise) associated with alleyways outweigh the benefits (e.g. connectivity and rear garage access.)

Accessibility

New Urbanists claim that accessibility to jobs, neighborhood amenities like parks, and commercial services are valuable to homeowners, but past studies analyzing the effect of proximity to the Central Business District (CBD) or employment centers on home values have found mixed results. Song and Knapp (2003), Troy and Grove (2008), Li and Brown (1980), Bowes and Ihlanfeldt (2001), Downes and Zabel (1997), and Cao and Cory (1981) found that as the distance from the CBD increases, holding other explanatory factors constant, home value

[4] Critics of suburban home design consider garages located in the front of the home to be an eyesore.

significantly decreases. Hess and Almeida (2007) found the opposite effect. It is likely that the opposite effect is due to the differences in the distribution of job centers outside the Buffalo CBD, compared to the job centers in the CBD of the other studies.

Various methods have been used to analyze the effect that commercial land use has on home values. Song and Knapp (2003) found that the straight-line distance to the nearest commercial use has a significant positive effect on home value, all else being equal. This finding is counter to the claim by New Urbanists that proximity to commercial services is of value to homeowners. Li and Brown (1980) took a more detailed approach to measure the effect commercial land use has on home values. They calculated the log of the distance to the nearest commercial use to measure the value of accessibility to commercial uses. Additionally, they calculated the negative exponent of the distance to the nearest commercial use to measure the negative external cost of commercial land uses. They found that as the logged distance to commercial land use increases, home values significantly decrease, indicating that accessibility to commercial uses is valued. Song and Knapp (2003) did not include other land use variables, unlike Li and Brown (1980), who included distance to industrial land uses. The difference in the findings between the two studies could be due to omitted variables in Song and Knapp's (2003) model.

Accessibility to parks, open spaces and gathering places for homeowners is another valuable component of neighborhoods, according to New Urbanists. Previous studies have measured the effect of distance to the nearest park on home value. Song and Knapp (2003) and Troy and Grove (2008) found that as the distance to the nearest park increases, home values significantly decrease, indicating that parks are a valuable neighborhood amenity. Yet Chen, Rufolo, & Dueker (1997) and Hess and Almeida (2007) found parks to have no significant effect on home value. However, Chen, Rufolo, & Dueker (1997) acknowledge that the lack of statistical significance could be due to multicollinearity. Hess and Almeida (2007) do not address the insignificance of parks in their analysis. It is likely; however, that multicollinearity is an issue with their model as well, due to the use of two different park measures.

Walkability

New Urbanists claim that walkability, broadly defined as the accessibility to public and private neighborhood services that are within walking distance (one-quarter mile) of residences, is of value to homeowners. Song and Knapp (2003) analyzed the walkability of neighborhoods by measuring the percentage of single-family residential (SFR) units within a quarter-mile of bus stops and commercial services. They found a positive relationship between the proportion of single-family homes and the proximity to commercial services. Interestingly, as reported above, they found the opposite effect: as distance from commercial services increases, home value increases. The walkability measure for bus stops was found to have a negative effect on home value.

Another study by Cortright (2009) analyzed the recent sales for over 90,000 homes in 15 different markets across the United States. He concludes that homes in highly walkable neighborhoods command a significant premium over other homes in less walkable neighborhoods, all else being equal. These results support the assertion by New Urbanists that walkability is valuable to homeowners.

Transportation mode choice

Alternative modes of transportation, especially light rail, are an important characteristic of New Urbanism, and New Urbanists claim that homeowners value such alternatives. The effect light rail has on home values have been widely studied. Bowes and Ihlanfeldt (2001) found that homes in Atlanta, Georgia located within a quarter-mile of a light rail station sell for a significant discount, compared to homes located further from a light rail station (p.15). This is perhaps because homeowners closer to the CBD are more concerned with the crime associated with light rail stops rather than the accessibility to the CBD. However, as distance from the CBD increases the negative effect of the station decreases and eventually becomes a positive effect on home value. This finding indicates that in suburban locations, the benefits of light rail access outweigh the negative externalities of light rail stops. Hess and Almeida (2007) and Chen, Rufolo, & Dueker (1997) found the opposite effect for homes located within a quarter of a mile from a light rail stop. The variation in the results is likely due to omitted variable bias and or due to the selection of irrelevant variables. Chen, Rufolo, & Dueker (1997) did not control for the effect of crime, unlike the other studies. Additionally, Bowes and Ihlanfeldt (2001) and Hess and Almeida (2007) used different measures of crime which could lead to different results.

Land use mix

New Urbanists claim that homeowners value neighborhoods that have a mix of public, private, commercial, and open space uses. Recent studies have analyzed how mixed land use affects home value. Song and Knapp (2003) used two measures of land-use entropy.[5] The first measure examines the diversity of five land-use categories: residential, commercial, multi-family, industrial, and public. They found a significant negative relationship between land-use mix and home value; as the mix of land-use types becomes more heterogeneous (i.e. increases) home value decreases. This finding contradicts New Urbanist claims and indicates that homeowners prefer neighborhoods that are predominantly single-family residential use (p. 231). The second measure is similar to the first one but excludes the residential land use. For non-residential land-use mix as the mix of non-residential land use types becomes more heterogeneous (i.e. increases) home value increases. This finding is supportive of the New Urbanist claim and indicates that households prefer neighborhoods with a more even mix of non-residential land uses (p. 231).

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[5] See Chapter 3: Methodology for further explanation of entropy.

Cao and Cory (1981) took a different approach to analyze the effect of mixed land uses on home value. Their study consists of two models, a zoning model and a land-use model. They found that in the Tucson, Arizona, the proportion of land zoned for single-family, multi-family, or commercial has no significant effect on home values. However, results from the land-use model show a significant relationship between home values and actual use of land (single-family, multi-family, or commercial). They conclude that the difference between the two models is evidence that “homeowners are more concerned with existing land-use mix than with probable future land-use configurations” (p. 15).

Jud (1980) found that homes located on residential zoned land sell for a significant price premium, compared to homes located on land zoned for other uses. The study also analyzed the effect of the proportion of non-residential (commercial, industrial, and vacant) land uses on home value. According to Jud (1980), the percentage of commercial land in a neighborhood has a significant negative effect on home value, yet the percentage of industrial land in a neighborhood has the opposite effect on home value. Furthermore, the percentage of vacant land in a neighborhood has no significant effect on home value. These results provide some support to New Urbanist claims that mixed land uses may be valuable to households.

Density

New Urbanists claim that compact neighborhoods, which provide accessibility to services within walking distance and support alternative modes of transportation, are more desirable compared to less compact neighborhoods. Population density and housing unit density are two ways to measure neighborhood compactness. Song and Knapp (2003), however, found that both population density and SFR housing unit density have a significant negative effect on home value, which contradicts New Urbanist claims. Two additional studies found population density (per square mile) to have no significant effect on home values (Clark and Herrin, 2000; Li and

Brown, 1980). The difference in the results between studies is most likely due to the use of different measures of population density. It is worth noting, however, that a study on self-reported individual happiness or satisfaction with life found that population density has a significant positive effect on a person's level of happiness and concludes that density is an amenity (Brereton, Clinch, & Ferreira, 2007).

What Control Variables Need to Be Included in a Hedonic Price Model?

In addition to urban form, neighborhood characteristics and housing characteristics also influence home values. Therefore, to control for the effect that urban form has on home value, it is important to include a review of empirical studies, which analyze housing characteristics and neighborhood characteristics. The effects of neighborhood characteristics and housing characteristics have been widely studied. Past studies have used the number of bedrooms, number of bathrooms, square footage, lot size, age of structure, and fireplaces as proxy variables to measure home value (Bowes & Ihlanfeldt, 2001). Studies analyzing the effects of neighborhood characteristics have used percent white, percent Hispanic, the percent of owner- occupied homes, household income, percent of persons with a bachelor's degree and the crime rate (Lynch & Rasmussen, 2001). Tables A2 and A3 in the appendix provide a summary of the empirical studies, the variables used, the significance of the results, and the magnitude that each control variable has on home value.

Neighborhood Characteristics

Background research shows that income, level of educational attainment, racial composition, crime, and school quality are neighborhood characteristics that significantly influence home value (Song & Knapp, 2003). According to O'Sullivan (2009), economic theory dictates that, "Households compete for places in a desirable neighborhood by bidding for housing and land in the neighborhood" (p.203). The positive externalities generated by higher-earning, better-educated neighbor’s drives the bidding process for homes. Safer neighborhoods, better networking opportunities and better educational opportunities for children are just a few desirable positive externalities. According to O’Sullivan (2009), “These positive externalities generally increase with income and education level, so people generally prefer neighborhoods with large numbers of high-income, educated households” (p. 202). Over time, the bidding up process leads to income segregated neighborhoods.

High-income households outbid lower-income households for homes in desirable neighborhoods causing home values. Of the studies reviewed, six studies found that income has a significant positive effect on home value (Troy and Grove, 2008; Bowes and Ihlanfeldt, 2001; Hess and Almeida, 2007; Kestens, Theriault, & Des Rosiers, 2006; Haurin and Brasington, 1996; Downes and Zabel, 1997). Yet Song and Knapp (2003), Li and Brown (1980), Clark and Herrin (2000), DeLisle, Huang and Liang (2006), and Lynch and Rasmussen (2001) found that income has no significant effect on home value. According to Li and Brown (1980), income is a proxy for other neighborhood characteristics. Thus, when income is used with only a few other neighborhood proxy variables, income tends to be statistically significant. However, the statistical significance of income diminishes, with the inclusion of more neighborhood variables (Li & Brown, 1980).

According to economic theory, educational attainment is expected to have a positive effect on home value. Past empirical studies have used the proportion of the population with a high school, bachelor’s, or master’s degree or greater as proxies for educational attainment. Brasington and Hite (2005), DeLisle, Huang, and Liang (2006), and Kestens, Theriault, & Des Rosiers (2006) found that as the percentage of persons with a university degree increases, home values significantly increase. Lynch and Rasmussen (2001) found the opposite effect, though there is no apparent reason why education would have a negative effect on home value. Other studies use the percentage of high school graduates to proxy for education. Troy and Grove (2008), for example, found the percent of high school graduates in a neighborhood has a positive effect on home value, yet Downes and Zabel (1997) found that the percentage of the population with a high school degree is not statistically significant. This is likely caused by the inclusion of other neighborhood-characteristic proxy variables, which closely correlate with the percentage of high school graduates.

Minority populations often are characterized as being less educated and earning less income when compared to white majority populations. The effect of race and ethnicity on home value has been widely studied. Past studies have analyzed the percentage of non-white minority populations (Asian, Black, and Hispanic) and the percentage of white population by neighborhood. Downes and Zabel (1997), Haurin and Brasington (1996), and Clark & Herrin (2000) found that minority populations have a significant negative effect on home values. Bowes and Ihlanfeldt (2001) found a similar negative effect for the percentage of Blacks. Yet Lynch and Rasmussen (2001) found that Hispanic populations have a significant positive effect on home values. The effect of white populations on home values tends to be positive. Lynch and Rasmussen (2001) and DeLisle, Huang, and Liang (2006) found that the percentage of the population that is white significantly increases home values. Yet Song and Knapp (2003) found that, the percentage of the population that is white has no significant effect on home values. They acknowledge, however, that their study area is predominantly white, which is likely the cause of the statistical insignificance.

According to economic theory, households bid for neighborhoods with quality schools. Therefore, school quality should have a positive influence on home value. The relationship between school quality and home value has been widely studied. Past studies have measured school quality by analyzing various standardized test scores (Scholastic Aptitude Test and state exams), teacher-student ratio, and dropout rates amongst other measures. Song and Knapp (2003), Clark and Herrin (2000), Haurin and Brasington (1996), DeLisle , Huang and Liang (2006), and Downes and Zabel (1997) found that both test scores and the passage rates of various schools have a significant positive effect on home values. The ratio of students to teachers is another proxy for school quality that past studies have analyzed. Song and Knapp (2003) and Clark and Herrin (2000) found (using opposite measures of teacher-student ratio) that schools with fewer students per teacher have a positive effect on home values. Other studies included high school dropout rates as a proxy for school quality. Clark and Herrin (2000), for example, found that high school dropout rates have a significant negative effect on home values, while Li and Brown (1980) find a similar negative effect; however, their result is not significant at the .05 level (p. 134).

Housing Structure Characteristics

Housing is a heterogeneous product made up of many different parts; e.g., rooms and siding. Using hedonic regression, these parts or characteristics are analyzed for the individual price effect that each characteristic has on home value. Numerous empirical studies have disaggregated housing characteristics into quantifiable variables. A meta study that reviewed 125 empirical studies found that the variables lot size, square footage, brick, number of bathrooms, number of rooms, number of full baths, the presence of a fireplace, the presence of air-conditioning, basements, the number of garage spaces, and the presence of a swimming pool show consistent results across all studies (Sirmans, MacDonald, Macpherson, & Zietz, 2006). These variables, generally thought to be amenities of a home are expected to have a positive effect on home value (Li & Brown, 1980). Yet the variables of age, the number of bedrooms, and time-on-market showed inconsistent results across all studies (Sirmans, MacDonald, Macpherson, & Zietz, 2006). Age is an indicator of quality and thus will have different effects depending on the sample of homes studied. The effect of the number of bedrooms tends to be inconsistent because more bedrooms in a home could mean the bedrooms are smaller, translating into lower home value (DeLisle, Huang, & Liang, 2006).

Of the individual studies reviewed, Song and Knapp (2003), Clark and Herrin (2000), Troy and Grove (2008), and Guttery (2002) analyzed lot size, square footage, and age. The studies find that lot size and square footage positively affect home value, while the age of a home negatively affects the value. They also used a quadratic age variable to test if age has a non-linear effect on home value, finding the quadratic age variable to be statistically significant and positive, indicating that age is non-linear. This means that depreciation reduces home value up to a certain age, then home value increases due to historical value.

Clark and Herrin (2000) and Bowes and Ihlanfeldt (2001) analyzed the effect that the number of bedrooms, bathrooms, and fireplaces have on home value. Bowes and Ihlanfeldt (2001) found that the number of bedrooms to significantly increase home values, while Clark and Herrin (2000) found opposite results. Both studies found that the number of bathrooms and the number of fireplaces significantly increase home value.

Hedonic Price Theory and Spatial Data

When analyzing spatial data, researchers must consider the spatial effects inherent in spatial data (Anselin & Getis, 1992). Spatial data is data that is represented by a specific geographic location (X and Y coordinates) or point in space. A single family home, for instance, has a specific X and Y location. On the other hand, non-spatial data, such as demographic data, does not have a specific X and Y location.

According to Tobler's First Law of Geography, "everything is related to everything else, but near things are more related than distance things" (Tobler, 1970). In terms of real estate, the law implies that the relationship between the values of homes near each other is stronger than the relationship between more distant homes. The spatial effect described by Tobler's law is also known as spatial dependence or spatial autocorrelation. Spatial autocorrelation violates the classical statistical assumption of independence. Potential flaws in parameter estimates and statistical significance tests can result if spatial autocorrelation is not corrected for in hedonic analysis (De Knegt, et al., 2010).

Moran's I and Geary's C are two commonly used statistical measures of spatial autocorrelation, while Spatial Lag and Spatial Error Models are two methods to correct for autocorrelation (Anselin, 1999). Spatial heterogeneity is another effect that should be accounted for when analyzing spatial data. According to Anselin and Getis (1992), "Spatial heterogeneity occurs when there is a lack of uniformity of the effects of spatial dependence and/or of the relationships between the variables under study" (p.24). Spatial heterogeneity (heteroskedacity) however, unlike spatial autocorrelation, can be corrected for using standard econometric tools (Anselin, 1999).

Of the fifteen studies reviewed that use spatial data, only three articles addressed the issue of spatial autocorrelation. Song and Knapp (2003) acknowledge the presence of spatial dependence in their data; however, they do not attempt to correct for it and present the standard OLS findings. Guttery (2002) addresses the issue of spatial autocorrelation, but reasons that his model adequately accounts for its effects. Troy and Grove (2008) used "a spatially adjusted regression model using a simultaneous auto-regression covariance family" (p.235) to adjust for spatial autocorrelation. Kestens, Theriault, & Des Rosiers (2006), tested for autocorrelation using Moran's I and Getis and Ord's zG*I measure of residuals. It is unclear why the majority of articles reviewed did not account for spatial effects. Many of the articles are more than 20 years old, and in those cases, the omission makes sense. However, articles less than ten years old should have at least addressed the issues associated with spatial data.

Conclusion: What Does This Mean for My Study?

Review of the literature of hedonic studies demonstrates that there is evidence that urban form significantly influences home values, but in different ways. Street design is a broad characteristic that is difficult to measure and is found to have varying effects on home values. The effect of density on home values garners less support by the literature. Only one study found that density significantly affects home value, while two other studies found density to have no significant effect on home values. Land use mix within a neighborhood has a significant effect on home values; although the direction of the effects is inconsistent. Proximity to light rail stations also is found to produce inconsistent results, although there is a significant effect on home values. Studies measured accessibility in different ways. Accessibility as measured by distance to CBD/ employment centers, distance to parks, and distance to commercial services has a significant effect on home values, however the results are inconsistent across studies. The same is true for walkability, which studies measure differently, but is found to have a significant effect on home values.

The evidence from the literature suggests that various neighborhood characteristics and housing characteristics influence home value. Income, educational attainment, white populations and school quality are found by the majority of studies reviewed to have a significant positive effect on home value. On the other hand, minority populations are found to have a significant negative effect on home value. Of the housing characteristics analyzed, there is evidence that the number of bathrooms, the presence of air conditioning, the presence of a basement, and the presence of a pool is found across all studies to be a significant and positive effect on home values. In addition, the number of fireplaces, the presence of an attached garage, and lot size show a positive effect but are not always significant. The number of bedrooms is found to be significant but influences home values in different ways.

So what does this mean for my study? Housing characteristics and neighborhood characteristics are significant factors in analyzing home values and therefore need to be included in my analysis of home values. There is also evidence, although limited, that urban form significantly influences home values. Therefore, further analyzing urban form and the effects on home values is of importance. While numerous studies have separately analyzed individual characteristics of urban form, very few have analyzed urban form as a whole. Therefore, the challenge lies in how to choose theoretically sound variables that proxy for urban form. Based on the literature reviewed, the definition and measurements of density, accessibility, land use mix, and transportation mode are straightforward. However, the definition and measurement of overall street design is more complicated. The diverse results found point to the need to start with a grounded hedonic theory of housing price that reduces the likelihood of omitted variable bias, chooses the appropriate functional form, and corrects for spatial autocorrelation and spatial heterogeneity.

Chapter 3

METHODOLOGY

Introduction

This section provides a detailed overview of hedonic price theory and how it is used to analyze the effects urban form has on home values. Next, the empirical model and functional form used to estimate home prices is presented. Thirdly, a detailed description of the key explanatory variables and control variables follows. Next, the data set used to develop the empirical model is described. Lastly, an explanation of the descriptive statistics follows.

Hedonic Price Theory

A parenthetical discussion of Studenmund's, *Using Econometrics: A Practical Guide*, (2006), is pertinent to understanding hedonic price theory. Hedonic price theory, also called hedonic regression uses statistics to show relationships or movements between data. For instance, there is a positive relationship between education and income; because as education increases income tends to increase, all else being equal. Hedonic regression is one of the strongest statistical tools utilized by academics and professionals to analyze the relationships and movements between data. Regression analysis "attempts to explain movements in one variable, the dependent variable (Y), as a function of the movement in a set of other variables, called the independent variable (X), through the quantification of a single equation" (Studenmund, 2006, p.6). The power of hedonic regression lies in its ability to determine the "strength and direction of the relationship" between data and to "test whether a significant quantitative relationship exists" (Studenmund, 2006, p.7). Hedonic regression, however, cannot prove the causality between the dependent variable and the independent variables. For a detailed discussion of hedonic regression, see appendix B.

Empirical Model

I hypothesize that urban form characteristics (U), neighborhood characteristics (N), and housing characteristics (H), are three broad categories that influence home value. A variation of Ordinary Least Squares (OLS) called multivariate regression analyzes the effects of multiple independent variables on the dependent variable, i.e. home value. The selling price transacted between 2008 and 2009 for all homes in the sample is the dependent variable.

Home Sale Price= *f*(U, N, H)

Choosing the functional form of the variables is the second step in constructing a theoretical hedonic model (Studenmund, 2006, p.68). Linear, double log, semi log, and polynomial are four functional forms commonly used for OLS regression analysis. The four functional forms fall into two categories, linear and nonlinear. The linear functional form is the most basic form. With the linear form, "the assumption [is] that the slope of the relationship between the independent and dependent variable is constant" (Studenmund, 2006, p.209). Interpretation of the estimated coefficients and calculation of the elasticities between the independent and dependent variables is easily calculated.

Researchers use the double log functional form, also called "log-log," when the relationship between the independent and dependent variable is nonlinear. Researches assume that the slope of the relationship between the independent and dependent variables is not constant but the elasticities are. With the log-log form, the natural log is taken for both the dependent and independent variables. The semi-log functional form is a combination of the double log form and linear form. With the semi-log form, the natural log is taken for either the dependent variable (log-linear) or the independent variable (linear-log).

The polynomial functional form is the fourth form. With the polynomial form, the independent variable is raised to a power greater than one (e.g. x^2). The shape of the slope follows a U-shape (x^2) or an S-shape (x^3). Researchers use the polynomial form when the relationship between the independent and dependent variable is nonlinear and takes on a slope different from that of the natural log. Polynomials may more accurately explain the effect that the age of a home has on its value compared to other forms. For example, initially as a home begins to age, its value will decrease up to a point. After that point, however, values may increase, possibly due to the historical value given to the structure.

In selecting the proper functional form, the theoretical relationship between the dependent variable and the independent variable is first considered. Past hedonic studies, which have analyzed home values, have used both log-semi and log-linear functional form. Based on the literature review I have chosen the log-linear functional form as the basis of analysis for the empirical model. I hypothesize that the relationship between the dependent variable and independent variables is not purely linear. The preferred specification is determined by how well the model performs. The R-squared value and the significance of the variables are two indicators of the performance of the model. Therefore, the model with the greatest R-squared value and the most number of significant variables is preferred. Equation 1 below presents a basic log linear model.

Equation 1: Log-Linear

$$Ln(P) = \beta_0 + \beta_i x_i + u$$

Standard hedonic price model using OLS regression where:

Ln(P)= natural log of sale price (2008-2009)

β_0 = estimated constant

$\beta_i x_i$ = estimated coefficient: β_i (i=39) are coefficients X_i (i=39) are variables

u= error term (normally distributed with a mean of zero)

The interpretation of the estimated coefficients in a log-linear form is as follows: For every one-unit increase in X, sale price is expected to change by X_i percent, all else being equal.

Urban form characteristics, neighborhood characteristics, and housing characteristics are functions of the following specific variables:

Urban Form characteristics = *f* (number of blocks, mean block perimeter, mean street length, ratio of street length to number of homes, ratio of street segments to intersections, cul-de-sac dummy, population density, housing unit density, land-use entropy, non-residential land-use entropy, distance to CBD, distance to commercial, distance to light rail stop, home within walking distance of a park dummy, home within walking distance of a commercial use dummy, home within walking distance of a light rail stop dummy)

Neighborhood characteristics = *f* (% bachelor's degree or greater, % owner occupied units, Academic Performance Index score, % black, % Hispanic, % Asian, poverty rate, median household income)

Housing Characteristics = *f* (square footage, number of bedrooms, number of full bathrooms, number of half bathrooms, lot size, number of garage spaces, CC&R regulations dummy, days on market, fireplace dummy, homeowners association dummy, pool dummy, real estate owned dummy, age, remodeled 2000-2010 dummy)

Description of Study Area

The City of Sacramento is the focus of this thesis. Sacramento is the capitol of California, the seventh largest city in the state, and the 35th-largest in the country, with a population of 466,488 people, according to the 2010 U.S. Census. The city covers an approximate area of 99 square miles. Other than being the capitol of California, Sacramento has nothing (location, job sector, etc.) unique that sets it apart from other similar-sized cities. Sacramento's demographics, household income, educational attainment, crime rate, median home value, population density, and commute time are comparable to nine other cities nationwide with similar populations (See table 1). The City of Sacramento is not known for New Urbanist development, unlike other cities (i.e. Portland, OR), meaning that the findings will be unbiased toward urban form that resembles New Urbanism. Finally, the City of Sacramento is not known as a destination city, which might bias home values. For these reasons, the city of Sacramento is an appropriate study area.

Table 1: Cities Comparable to Sacramento

City Name	Population	Median Household Income (2009)	Crime Rate	Median Home Value	Population Density (per sq mi)	University Education	Commute Time (min)	% Black	% Hispanic	% Asian
Sacramento, CA	466,687	$47,107	495	$250,300	4803	24%	23.4	13%	25%	18%
Mesa, AZ	462,486	$49,446	302	$173,100	3700	22%	25.9	3%	25%	2%
Northeast Jefferson, CO	451,811	$63,552	N/A	$250,578	2615	33%	25.3	1%	11%	2%
Kansas City, MO	482,299	$41,999	661	$138,300	1538	26%	21.9	28%	10%	2%
Omaha, NE	454,731	$46,595	376	$134,600	3930	29%	18.2	12%	11%	2%
Raleigh, NC	405,791	$51,969	311	$214,900	3541	45%	22	30%	10%	4%
Cleveland, OH	431,363	$24,687	766	$84,000	5560	11%	25.8	50%	9%	1%
Portland, OR	566,141	$50,203	383	$296,100	4215	33%	23.1	6%	9%	6%
Northwest Harris, TX	464,301	$72,852	N/A	$175,328	1061	35%	29.7	10%	15%	5%
Fresno, CA	479,921	$43,223	412	$208,100	4599	19%	21.7	8%	46%	11%

Source: city-data.com

What Defines a Neighborhood?

A clear definition of a neighborhood is required to control for neighborhood effects. Past studies have relied upon well-defined geographic boundaries due to the complicated nature of delineating neighborhoods based on socioeconomics. Census tracts, census block groups, and census sub-block groups, for example, are three possible ways to define a neighborhood. Song and Knapp (2003) analyzed the change in urban form characteristics over time and found that census block groups show the most relevant information, when compared to census tracts and census sub-block groups. On the other hand, Cao and Cory (1981) used census tracts to define a neighborhood. Ultimately, there is no consistent definition of a neighborhood based on the review of literature. Therefore, for the purpose of this thesis, I have chosen census tracts to define a neighborhood.[6] The City of Sacramento has 103 census tracts (see figure 1). Of the 103 census tracts, home sales data is available for 88 of them.

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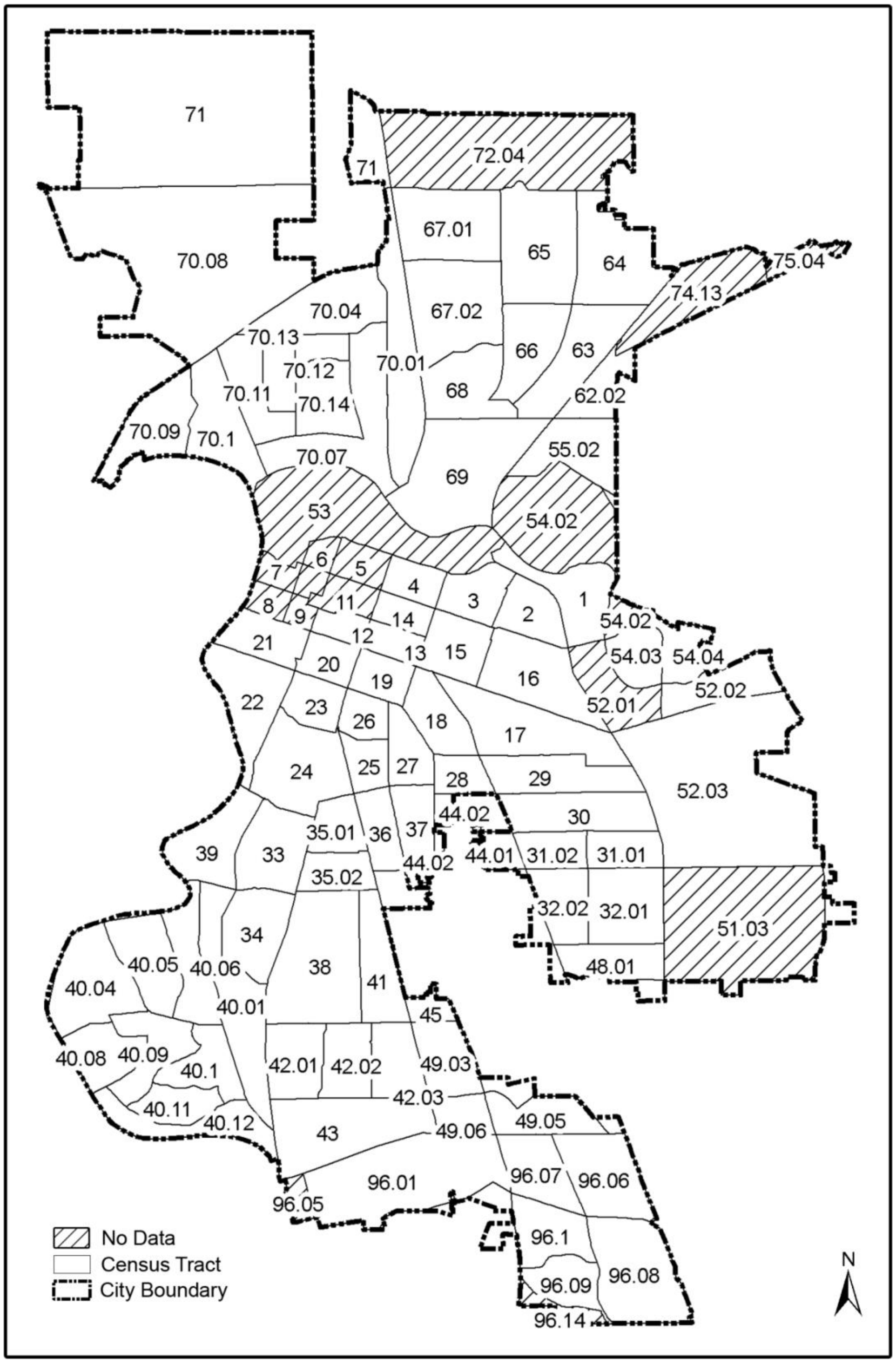
[6] I did consider census block groups as a measure of neighborhoods; however, due to the lack of time and resources required to aggregate the data at the block level, I chose census tracts instead.

Figure 1: City of Sacramento Census Tract Map



Urban Form Explanatory Variables

Street design, density, accessibility, land use mix, and walkability are five broad categories that proxy for urban form. Table 2 provides a detailed definition and the expected effect of the specific explanatory variables that proxy for each broad category of urban form.

Street Design

According to New Urbanists, street network pattern is an important indicator of how well the accessibility and connections are within a neighborhood. Street network pattern ranges from grid-like patterns found in older traditional neighborhoods to curvilinear street patterns with cul-de-sacs found in suburban neighborhoods. Grid-like street patterns are more connected, offer more travel options, and typically exhibit traffic at lower speeds, making it safer for pedestrians, bicycles, cars, and emergency vehicles, according to New Urbanists. Curvilinear street patterns, by contrast, have fewer connections, offer fewer travel options, and typically exhibit traffic at greater speeds, making it less safe for pedestrians and bicyclists.

Six variables based on Song and Knapp (2003) proxy for street pattern. Segments (streets), nodes (intersections and cul-de-sacs), and blocks define street pattern. The specific variables that proxy for street pattern are: (1) number of blocks; (2) cul-de-sac dummy; (3) block perimeter; (4) ratio of street length to homes; (5) mean street length; and (6) the ratio of street segments to intersection. All variables are calculated using GIS tools and aggregated at the census tract level.

According to New Urbanists, more streets, more intersections, smaller blocks and fewer cul-de-sacs should increase the connections and travel options within neighborhoods; in theory, these characteristics should increase home value. Therefore, I predict the ratio of street segments to number of intersections, the cul-de-sac dummy, street length, and the number of blocks to have a positive effect on home value. The opposite is predicted for block perimeter, which is expected to have a negative effect on home values. Finally, the effect on home value of the ratio of street length to the number of homes is uncertain.

Density

New Urbanists also argue that higher housing-unit densities are a more efficient use of land and infrastructure. Traditional neighborhoods typically have higher densities, due to the higher opportunity cost of travel and the trade-off between the location of home and employment. Suburban neighborhoods, on the other hand, typically have lower densities due to the lower opportunity cost of travel resulting from the widespread use of the automobile.

Neighborhood population density and housing unit density are two variables that proxy for density. Population density measures the number of residents per acre. Housing unit density measures the number of homes per acre.[7] Although, New Urbanists view density as an amenity, the literature does not support their claim. Therefore, I predict that both measures of density will have a negative effect on home value.

Land use mix

The mix or diversity of land uses is measured using entropy.[8] Land use mix is an indicator of how well residential, commercial, open space, and industrial uses are balanced within a neighborhood. According to New Urbanists, a mix of land uses offers residents more opportunities to walk, bike, or use mass transportation to reach local jobs and retail services. Typically, traditional neighborhoods have a greater mix of uses, compared to suburban neighborhoods, which typically are solely residential land use.

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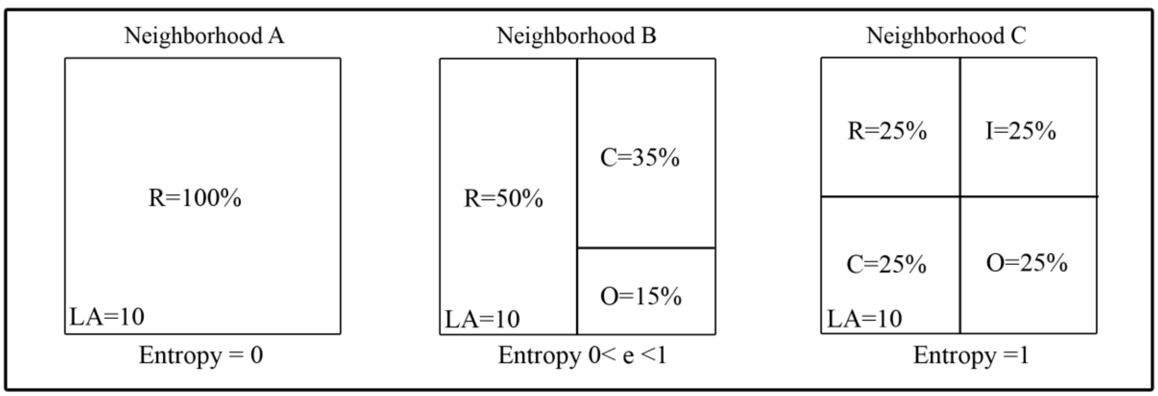
[7] According to the U.S. Census "A housing unit may be a house, an apartment, a mobile home, a group of rooms, or a single room that is occupied (or, if vacant, is intended for occupancy) as separate living quarters."

[8] Entropy is based on the second law of thermodynamics and the statistical mechanics definition of entropy that was developed by Ludwig Boltzmann in 1870s (Entropy, 2011).

Land use entropy and non-residential land use entropy proxy for land use mix (Song & Knapp, 2003). Land use entropy measures the mix of land uses within a neighborhood.[9][10] Land-use entropy is either one, indicating the neighborhood has a perfect mix (heterogeneous) of land use types, such as that found in a central business district, or zero, indicating the neighborhood has only one land use type (homogeneous), such as is seen in rural residential areas. The entropy calculation uses Sacramento's four land use categories: commercial (C), residential (R), industrial (I), and open space/agricultural (O). See **Error! Reference source not found.** for further explanation.

Figure 2: Concept of Entropy



Error! Reference source not found. shows three "neighborhoods" represented by squares that are each 10 square miles (LA=10). Neighborhood A has one land use type, residential, which makes up 100% of the land area. Therefore, the land use entropy (e) of neighborhood A is zero or perfectly homogenous. Neighborhood B has three land use types, residential, commercial, and open space. Residential makes up the majority of neighborhood B, followed by commercial, and

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[9] Land use Entropy = { - Σk [(pz) (ln pz)]}/(ln b).
Where "pz" is the area of land in the zth land types. K is the total number of land use types.

[10] See M. Turner, R.H. Gardner, R.V. O'Neill (2001), and Kockelman, K. M. (1997) for similar uses of entropy as a measure of distribution, but not necessarily land use distribution.

next by open space. Neighborhood B has land use entropy (e) between zero and one. Neighborhood C has four land use types, residential, commercial, open space, and industrial. The four land use types make up 25% of the land area of neighborhood C. Therefore the land use entropy (e) of neighborhood C is one, or perfectly heterogeneous. The same would be true for neighborhood C if there were only two land use types, say 50% residential and 50% open space, as in this case land use entropy is still equal to one.

The first measure, land use entropy, calculates the mix of all four land-use categories in a neighborhood. The second measure, non-residential land use entropy, is similar to the first measure, but excludes residential land use in the calculation. I predict that heterogeneous mix of land uses (indicated by the variable land use entropy) will have a positive effect on home value. It is uncertain, however, what effect non-residential land use entropy will have on home value.

Accessibility

Accessibility analyzes the effect that distance to employment centers, commercial services, and transportation infrastructure has on home value. New Urbanists claim that the single land use, auto-oriented design of suburban development reduces accessibility. They argue that by increasing accessibility to the aforementioned elements, people will drive less and experience less stress. In theory, the benefits of accessibility should translate into higher home values.

Using GIS tools, I created four variables for each home address in the City of Sacramento. The variables that proxy for accessibility includes: (1) distance to CBD; (2) distance to commercial zone; (3) distance to light rail stop; and (4) distance to freeway on-ramp. I expect that as the distance increases home value will decrease all else being equal.

Walkability

Walkability analyzes the price effect on properties that are within walking distance (1400 feet) to parks, commercial and retail services, and mass transportation. New Urbanists claim that the single land use, auto-oriented design of suburban development is not walkable, which forces residents to drive, even for short trips. Similar to their argument for accessibility, New Urbanists assert that by increasing neighborhood walkability to the aforementioned elements, people will drive less and experience less stress. In theory, the benefits of walkability should translate into higher home values.

Together, three dummy variables proxy for walkability. Using a dummy variable (1,0), each home location is evaluated for the ability of the household inhabitants to walk (within 1400 feet) to the nearest park, commercial area, and light rail stop. Homes within walking distances of a park are expected to sell for a premium. Commercial and retail services are defined as the nearest commercial zone (based on the city of Sacramento zoning map). Proximity to commercial and retail services is expected to have a positive effect on home value, as is proximity to a light rail station.

Table 2 Definition of Urban Form Variables

Variable Name	Definition	Source	Predicted Direction
Dependent Variable			
Sales price	Sales price (2008-2009)	MLS	
Independent Variables			
Street Pattern/ Circulation			
Ratio of street length to # of homes	Street length divided number of homes in CT (per acre)	CDD GIS Data	Uncertain
Ratio of street segments to intersections	Number of street segments divided by number of intersections (nodes) (per acre)	CDD GIS Data	Positive
Cul-de-sac dummy	Dummy: 1=home is within 100 feet of cul-de-sac	CDD GIS Data	Positive
Block perimeter	Median perimeter of all blocks by CT (per acre)	CDD GIS Data	Negative
Number of blocks	Number of city blocks per CT (per acre)	CDD GIS Data	Positive
Mean street length	Mean of street length in CT (per acre)	CDD GIS Data	Positive
Density			
Population density	Population of CT/ area of CT multiplied by 43,560 sq feet	2000 Census	Negative
Housing unit density	Number of housing units in CT/ area of CT multiplied by 43,560 sq feet	2000 Census	Negative
Land Use Mix			
Land use entropy	Enthrotropic mix of land uses, values between 1 and 0, 1 being perfectly heterogeneous, 0 being perfectly homogenous. Includes all four land uses	CDD GIS Data	Positive
Non-residential land use entropy	Same as land use entropy but does not include residential land use	CDD GIS Data	Uncertain

Accessibility			
Distance to commercial	Straight-line distance to the nearest commercial land use in feet	CDD GIS Data	Negative
Distance to light rail station	Straight-line distance to the nearest light rail station in feet	CDD GIS Data	Uncertain
Distance to central business district	Straight-line distance to central business district in feet	CDD GIS Data	Negative
Distance to freeway on-ramp	Straight-line distance to the nearest major road in feet	CDD GIS Data	Negative
Walkability			
Home within 1400 feet of a park	Dummy: 1= home is within 1400 feet of park, 0=otherwise	CDD GIS Data	Positive
Home within 1400 feet of commercial service	Dummy: 1= home is within 1400 feet of commercial land use, 0=otherwise	CDD GIS Data	Positive
Home within 1400 feet of a light rail stop	Dummy: 1= home is within 1400 feet of light rail stop, 0=otherwise	CDD GIS Data	Positive

Control Variables

Urban form alone cannot explain home value; therefore, two sets of control variables (housing characteristics and neighborhood characteristics) are included in the model to estimate the price effect that urban form has on home values. Fourteen variables, mainly related to the physical structure of the home and the land where the home is located proxy for housing characteristics. Eight variables related to the socioeconomic makeup of each neighborhood proxy for neighborhood characteristics. Table 3 provides a definition and the expected effect of the control variables.

Housing variables

The structural and physical characteristics of a home are typical measures used to derive home value. The proxy variables for home characteristics are selected based on previous research discussed in the literature review and the availability of certain variables. The key variables include square footage, number of bedrooms, swimming pool dummy variable, and age. Other variables include the number of days the home was on the market between 2008 and 2009, lot size, number of full bathrooms, number of half bathrooms, number of garage spaces, a real estate owned dummy variable, fireplace dummy variable, and a home remodel (between 2000 and 2010) dummy variable.

I predict that the majority of the variables representing physical characteristics of the house (i.e. number of bathrooms, square footage, and other amenities) will have a positive effect on home value. The age as well as whether the home was real estate owned are expected to have a negative effect on home value. However, the effects on home value of the number of bedrooms, CC&R regulations, and the amount of time the house was on the market are uncertain.

Neighborhood variables

Income, school quality, educational attainment, poverty rate, and race proxy for neighborhood characteristics based on previous research. Income is measured by median household income in 1999. Income is predicted to have a positive effect on home value. The Academic performance Index (API) scores of schools in each census tract proxies for school quality.[11] School quality is predicted to have a positive effect on home value. Educational attainment is measured by the proportion of the population with a university degree or greater. Educational attainment is predicted to have a positive effect on home value. Poverty rate is measured by the percentage of incomes (1999) that are below the poverty line. Poverty rate is predicted to have a negative effect on home value. The proportion of Black, Hispanic and Asian populations measures the racial makeup of a neighborhood. I predict that Black and Hispanic populations will have a negative effect on home value, but the effect of Asian populations is uncertain.

[11] API score date obtained for the City of Sacramento was not complete; i.e. missing values were found. The SPSS "series mean estimation method for replacing missing values" is used to estimate the missing API values. The missing values are replaced with the mean value of all API scores.

Table 3: Definition of Housing and Neighborhood Variables

Variable Name	Definition	Source	Predicted Direction
Housing Characteristics			
Square footage of home	Square footage of home	MLS	Positive
Number of bedrooms	Number of bedrooms	MLS	Uncertain
Number of full bathrooms	Number of full bathrooms	MLS	Positive
Number of half bathrooms	Number of half bathrooms	MLS	Positive
Number of garage spaces	Number of garage spaces, including carports	MLS	Positive
CC&R dummy	Dummy: 1=home is subject to CC&R regulation, 0=otherwise	MLS	Uncertain
Days on market	Number of days on market	MLS	Uncertain
Fireplace dummy	Dummy: 1=home has at least one fireplace, 0=otherwise	MLS	Positive
Homeowner association dummy	Dummy: 1= homeowner pays HOA dues, 0=otherwise	MLS	Uncertain
Lot size	Square footage of lot	MLS	Positive
Pool dummy	Dummy: 1=home has a pool, 0=otherwise	MLS	Positive
Real estate owned home (REO)	Dummy: 1=home was real estate owned, 0=otherwise	MLS	Negative
Age	Age of home in 2011	MLS	Negative
Home remodeled between 2000 and 2010	Dummy: 1=home was remodeled between 2000 and 2010, 0=otherwise	MLS	Positive
Neighborhood Characteristics			
Percent bachelor’s degree or higher	Percentage of population with a bachelor’s degree or greater per CT	2000 Census	Positive
Percent owner-occupied units	Percentage of owner occupied units per CT	2000 Census	Positive
Household income	Median household income in 1999	2000 Census	Positive
API scores	Academic performance Index	California DOE	Positive

Percent Black	Percentage of Black population by CT	2000 Census	Negative
Percent Hispanic	Percentage of Hispanic population by CT	2000 Census	Negative
Percent Asian	Percentage of Asian population by CT	2000 Census	Uncertain
Poverty rate	Percentage of population with income below 1999 poverty line by CT	2000 Census	Negative

Data Description and Descriptive Statistics

The sample data was gathered from four sources. Housing related data was obtained from Multiple Listing Service (MLS) for the Sacramento six county regions.[12] Demographic, economic, and educational data for the City of Sacramento was compiled from the 2000 U.S. Census SF3 data tables. (All census data was aggregated at the census tract level). GIS shape files for land use, streets, parks, parcels, major roads, highways, light rail, and intersections was collected from the City of Sacramento Community Development Department. Finally, spatial data was calculated using ArcMap™ version 9.3 and version 10.

Urban form statistics

Error! Reference source not found. presents the mean, standard deviation, minimum, and maximum values of all the variables. Streets, blocks, and nodes make up a neighborhood's street pattern. Neighborhoods on average have 97 blocks, which have perimeters that range from 940 feet to 6000 feet. Intersections and cul-de-sacs define nodes. Neighborhoods on average have 30 cul-de-sacs, over 220 intersections, and more than 33 miles of streets. Multiple connected segments make up streets, and neighborhoods on average have 400 street segments. The average ratio of street segments to intersection is 1.7. The ratio of streets to homes is on average 239 feet per home. On average, there are 59 blocks per 500 homes per neighborhood. Finally, only three percent of homes are located within 100 feet of a cul-de-sac.

Density consists of population density and housing unit density. Population densities range from less than one person per acre to more than 17 people per acre. Neighborhoods on average have a population density of 8.3 people per acre. Housing unit density ranges from less than one unit per acre to more than 39 units per acre. Neighborhoods on average have 4.4 units per acre.

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[12] A Sacramento Realtor/ULD Student compiled all housing characteristic data between 2008 and 2009.

The land use mix (entropy) of neighborhoods in the study area is as follows. Land use mix is measured on a scale of zero (homogeneous) and one (heterogeneous). On average land use entropy is 0.57, while non-residential land use entropy is 0.47.

Homes on average are located 1300 feet from the nearest commercial land use, and 64 percent of homes are within walking distance of commercial land use. Homes on average are located more than five miles from the CBD. Light rail stations on average are located more than a mile away from the homes in the sample, and only six percent of those homes are located within walking distance of a light rail station. Homes on average are located within a mile of a freeway on-ramp. Sixty-one percent of homes are located within walking distance of a park.

Housing statistics

The sample of 10,052 homes had an average of three bedrooms, two full bathrooms, less than one half bathroom, 1.7 garage spaces, and were on average 35 years old, with the oldest home being 130 years old. The square footage of homes ranged from 450 square feet to 5600 square feet, averaging 1500 square feet. Lot sizes ranged from 436 square feet to 43,560 square feet, averaging 6400 square feet. Seven percent of the homes had a pool. Less than 3% of the homes were remodeled between 2000 and 2010. Some 80% of the homes were located in neighborhoods with CC&R regulations, while 12% of the homes were part of a homeowners association. Real estate owned properties made up 72 percent of the homes sampled. There was a fireplace in 67% of the homes. Lastly, the homes for sale spent an average of 53 days on the market between 2008 and 2009, and sold for an average of $181,200.

Neighborhood statistics

The study area consisted of 88 neighborhoods. Neighborhoods on average had 4800 residents. There are on average 1600 homes in each neighborhood. Minority populations (Blacks, Hispanics, and Asians) made up less than 25% of the average neighborhood population. Median household income in 1999 ranged from $18,000 to over $79,000, while the average household income was $40,000. Owner occupancy rates averaged 60%. Neighborhood poverty rates ranged from 1.5% to over 40%. The average API score for schools across all neighborhoods was 733. Percent of population with a university education ranged from 3% to over 60%, and on average, 18% of neighborhood residents had a university education.

Table 4: Descriptive Statistics

Variable	Unit of Measure	Min	Max	Mean	Std. Deviation
Dependent variable					
Selling price	Dollars	6053.00	975000.00	181193.39	119258.18
Urban form					
Number of blocks	# of blocks	8.00	312.00	96.75	88.99
Number of blocks per acre	# / acre	.01	.45	.0920	.07235
Ratio of blocks to # of homes	Ratio	.01	.61	.12	.19
Ratio of blocks to # of homes per acre	Ratio	.00	.00	.0001	.00005
Block perimeter	Feet	940.49	5945.57	2423.89	531.78
Block perimeter per acre	Feet	.09	17.83	3.8949	2.91838
Cul-de-sac dummy	Binary	.00	1.00	.03	.18
Distance to commercial	Feet	.00	5625.58	1263.91	916.98
Distance to CBD	Feet	3325.11	55266.69	27939.41	10382.87
Distance to light rail station	Feet	134.04	23265.74	5785.08	3784.75
Variable	**Unit of Measure**	**Min**	**Max**	**Mean**	**Std. Deviation**
Distance to freeway on-ramp	Feet	54.46	12469.64	4401.75	2718.64
Housing unit density	#/acre	.20	39.06	4.39	3.59
Land use entropy	Proportion	.05	1.00	.57	.21
Non-residential land use entropy	Proportion	.00	1.00	.47	.28
Population density	#/acre	.04	17.98	8.29	5.24

Street segments per intersections	Ratio	1.16	4.80	1.74	.33
Street segments per intersections per acre	Ratio	.00	.01	.0027	.00198
Ratio of street length to # of homes	Ratio	12.24	1344.36	238.96	431.43
Ratio of street length to # of homes per acre	Ratio	.01	.27	.0846	.04293
Mean street length	Feet	256.33	842.80	416.3695	59.67014
Mean street length per acre	Feet	.02	2.42	.6533	.43820
Home within 1400 feet of commercial service	Binary	.00	1.00	.64	.48
Home within 1400 feet of a light rail stop	Binary	.00	1.00	.06	.23
Home within 1400 feet of a park	Binary	.00	1.00	.61	.49
Housing					
Age	Years	1.00	130.00	35.41	25.51
Number of full bathrooms	Number	1.00	5.00	1.86	.62
Number of half bathrooms	Number	.00	2.00	.19	.40
Number of bedrooms	Number	1.00	9.00	3.17	.79
CC&R dummy	Binary	.00	1.00	.80	.40
Days on market	Days	.00	605.00	52.92	64.77
Fireplace dummy	Binary	.00	1.00	.67	.47
Home owner association dummy	Binary	.00	1.00	.12	.32
Lot size	Square feet	436.00	43560.00	6426.45	2584.32
Variable	**Unit of Measure**	**Min**	**Max**	**Mean**	**Std. Deviation**
Number of garage spaces	Number	.00	5.00	1.68	.74
Number of fireplaces	Number	.00	4.00	.70	.52
Pool dummy	Binary	.00	1.00	.07	.25
Home remodeled 2000-2010	Binary	.00	1.00	.03	.17
Real estate owned home (REO)	Binary	.00	1.00	.72	.45

Square footage of home	Square feet	432.00	5583.00	1490.13	562.77
Neighborhood					
API score	Score	495.00	926.00	733.38	59.31
Household income	Dollars	18341.00	78611.00	40434.67	14262.56
Percent Asian population	Percentage	.96	43.24	15.41	9.96
Percent bachelor's degree	Percentage	2.90	63.43	18.36	13.60
Percent Black population	Percentage	.21	37.41	15.25	10.67
Percent Hispanic population	Percentage	5.13	50.53	22.82	9.08
Percent owner occupied units	Percentage	4.00	90.00	60.48	17.15
Poverty rate	Percentage	1.57	42.65	20.21	11.29

Chapter 4

RESULTS

Introduction

This chapter discusses the specification used to analyze the set of data and the rationale for choosing the preferred specification. First, I explain the procedure for testing and correcting for violations of the classical assumptions. Next is a discussion of the regression results for the final preferred specification. Finally, I discuss the method used to determine the premium for New Urbanist characteristics.

Initial Regression Model

Table 5 presents the results for the initial uncorrected log-linear model. Column 1 presents the beta coefficients from the estimated regression model. Column 2 presents the t-ratio value for the estimated intercept and all the independent variables. Column 3 presents the P-value or significance of each independent variable. Finally, column 4 presents the variance inflation factor (VIF) for each variable.[13]

The t-ratio (t) and P-value (sig) are used to test the null hypothesis. The null hypothesis states that there is no relationship between the independent variable (urban form, housing, and neighborhood) and the dependent variable (sale price) and that the estimated coefficient is equal to zero. The t-test is used to create confidence intervals. Ninety percent, 95 %, and 99% are typical levels of confidence used for hypothesis testing. The null hypothesis can be rejected for t-values with an absolute value greater than 1.645. The critical t-value 1.645 is for a 10% two-tailed significance test. For a one percent two-tailed test, the critical t-value is 2.576. Similarly, the P-value (sig) is the probability (0-1) of observing t-values large enough to reject the null

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[13] The variance inflation factor is an indicator of possible multicollinearity and is discussed later in the chapter.

hypothesis. The smaller the P-value the greater the probability the estimated result is different from zero, which means the null hypothesis, can be rejected. If the P-value (sig) is greater than 0.1 for a 10 percent two-tailed test the null hypothesis cannot be rejected. For a one percent two-tailed test if the P-value is greater than 0.001 the null hypothesis cannot be rejected.

The R-squared value of 0.787 indicates the hedonic model explains 78.7% of the variation in the home values in the sample. The majority of urban form variables are significant at the 90% confidence level. All housing variables, except the variable pool dummy, are significant at the 90% confidence level or greater. All neighborhood variables are significant at the 90% confidence level or greater.

Table 5: Uncorrected Regression Results

Variable Name	Estimated Beta Coefficients	t	Sig.	VIF
(Constant)	11.6292876 *** (0.076)	152.311	.000	
Age	-.0044246 *** (.000)	-20.273	.000	3.324
API score	-.0001589 ** (.000)	-2.245	.025	1.890
Number of full bathrooms	.0574059 *** (.009)	6.252	.000	3.428
Number of half bathrooms	.0266959 *** (.009)	2.933	.003	1.391
Number of bedrooms	.0142227 ** (.006)	2.379	.017	2.384
Number of blocks	1.1107203 *** (.117)	9.525	.000	7.632
Block perimeter	-.0291819 *** (.004)	-7.272	.000	14.708
CC&R dummy	-.0276587 *** (.008)	-3.476	.001	1.081
Cul-de-sac dummy	-.0141523 (.017)	-.815	.415	1.021

Distance to commercial	.0000035 (.000)		.568	.570	3.366
Distance to CBD	-.0000052 (.000)	***	-9.136	.000	3.730
Distance to light rail station	-.0000078 (.000)	***	-7.289	.000	1.738
Distance to freeway onramp	.0000035 (.000)	**	2.221	.026	1.975
Days on market	-.0002264 (.000)	***	-4.675	.000	1.055
Fireplace dummy	.1427849 (.008)	***	18.165	.000	1.466
Housing unit density	.0091603 (.002)	***	4.751	.000	5.137
Home owner association dummy	-.0463693 (.013)	***	-3.562	.000	1.895
Lot size	.0000033 (.000)	**	2.428	.015	1.292
Land use mix (entropy)	.0791410 (.028)	***	2.815	.005	3.847
Mean street length	.5668985 (.033)	***	17.292	.000	22.130
Household Income	-.0000030 (.000)	***	-3.668	.000	14.944
Number of garage spaces	.0708685 (.006)	***	12.409	.000	1.925
Non-residential land use mix	-.0530848 (.018)	***	-2.917	.004	2.708
Percent Asian population	.0042789 (.001)	***	8.326	.000	2.811
Percent bachelor’s degree	.0176863 (.001)	***	22.697	.000	12.037
Percent Black population	-.0061116 (.001)	***	-11.883	.000	3.226
Percent Hispanic population	-.0074775 (.001)	***	-10.739	.000	4.288
Percent owner occupied units	.0020855 (.001)	***	4.052	.000	8.349
Poverty rate	-.0044848	***	-5.500	.000	9.081

	(.001)				
Pool dummy	.0163360 (.013)		1.302	.193	1.097
Population density	-.0131352 (.002)	***	-6.237	.000	13.042
Home remodeled 2000-2010	.1650045 (.019)	***	8.681	.000	1.074
Real estate owned home (REO)	-.2708779 (.008)	***	-33.529	.000	1.424
Square footage of home	.0003398 (.000)	***	30.350	.000	4.258
Ratio of street length to # of homes	-2.6295361 (.188)	***	-13.955	.000	7.016
Street segments per intersections	-27.515537 (6.639)	***	-4.145	.000	18.454
Walking distance of a commercial use	.0066744 (.011)		.601	.548	3.065
Walking distance of a light rail stop	-.0009584 (.014)		-.067	.947	1.202
Walking distance of a park	-.0228185 (.008)	***	-2.853	.004	1.626
R-squared Observations	.787 10052				
*Significant at the 90% confidence interval, ** Significant at the 95% confidence interval, *** Significant at the 99% confidence interval, (.000) Standard error					

Violations of Classical Assumptions

To produce significant and reliable results, the OLS regression technique must adhere to seven classical assumptions. Violation of any of these classical assumptions can lead to a number of estimation errors. Multicollinearity and heteroskedasticity are two errors found in cross-sectional studies such as this one.[14] The correction of these errors is vital in order to produce

[14] Spatial autocorrelation is a third type of error that can lead to estimation errors. There is evidence of significant spatial autocorrelation based on the calculated Moran's I. No attempt however is made to correct for spatial autocorrelation. The author leaves the correction of autocorrelation for future research.

significant reliable results. The following discussion explains the steps taken to correct for multicollinearity and heteroskedasticity.

Multicollinearity is "a linear functional relationship between two or more independent variables that it is so strong that it can significantly affect the estimation of the coefficients of the variables" (Studenmund, 2006 p. 249). The Persons correlation coefficient test is used to measure the strength of the relationship between the variables. Analyzing the correlation between variables is important for two reasons; 1) the reported coefficients between (+one and -one) help to describe the significance of the relationship between the variables, and 2) functions as a test for multicollinearity.

Based on the Persons test correlation coefficients, six variables (number of blocks, ratio of street length to number of homes, and ratio of blocks to number of homes) are highly correlated with each other. The correlation between number of blocks, the ratio of street length to the number of homes and ratio of blocks to the number of homes is understandable. The reported correlation coefficients between the variables are all greater than 0.80 and significant at the 0.01 level meaning the inclusion of these highly correlated variables may raise concerns of possible multicollinearity.

The variance inflation factor (VIF) is another test for multicollinearity. Variables with VIF's greater than five and are not statistically significant might be evidence of possible multicollinearity. According to Table 5, the number of blocks, mean perimeter of blocks, mean street length, housing unit density, ratio of street segments to intersections, ratio of street length to number of homes, median household income, percent university degree, percent owner occupied, percent poverty, and population density all report VIF's greater than five. All eleven variables however are statistically significant and therefore remain in the model.

Heteroskedasticity is present when the variation between explanatory variables is not constant. Incorrect model specification and or "omitted variables can cause a heteroskedastic error term because the portion of the omitted effect not represented by one of the included explanatory variables must be absorbed by the error term" (Studenmund, 2006 p. 352). Before testing for heteroskedasticity, it is important to first gain an understanding of the theoretical basis of the relationships and magnitudes of all the explanatory variables before considering the specification of the model.

To test for heteroskedasticity, first, I hypothesize that the variable lot size could potentially have variance that is not constant across the sample. Second, the unstandardized residuals from the log-linear regression are squared and logged; similarly, I take the log of the variable lot size. Third, following the steps for the Park Test, I ran a regression using the log of the squared residuals as the dependent variable, with the log of the variable lot size as the independent variable. By examining the reported t-score (5.638) from the regression output, a hypothesis test determines if the variable is causing heteroskedasticity. The critical t-value for a one percent two-tailed test is 2.576. The null hypothesis (homoskedasticity) can be rejected if the absolute value of the calculated t-score from the Park Test is greater than 2.576. According to the calculated t-score the null hypothesis is rejected, meaning there is evidence of heteroskedasticity. To correct for heteroskedasticity I use the Weighted Least Squares (WLS) method to reduce the variance in the error term by dividing the log-linear equation by a proportionality factor Z (lot size).[15]

[15] See Studenmund (2006) for further explanation of the weighted least squares correction for heteroskedasticity.

Results: Log-linear Model

Table 6 presents the results for the corrected log-linear model. Correcting for heteroskedasticity has no effect on the R-squared value. The R-squared value of 0.787 indicates that the model explains 78.7% of the variation in the home values in the sample. Twelve of the 17 urban form variables are significant at the 90% confidence level or greater. All housing variables are significant at the 90% confidence level or greater.[16] Seven of the eight neighborhood variables are significant at the 90% confidence level or greater.[17]

The second column presents the coefficient elasticity and the confidence intervals for all the variables. Correctly interpreting the elasticities of the estimated coefficients is crucial in determining to what degree the key explanatory variables affect home prices. Because the log-linear form is non-linear, I use elasticity to interpret the coefficients. Elasticity measures the magnitude or slope of the estimated coefficients at a single point, holding all else constant. The higher the elasticity the greater the effect the estimated coefficient has on the dependent variable i.e. sale price. The estimated coefficients for the log-linear specification are interpreted as the percentage change in the home price associated with a one-unit change in the explanatory variables. This study evaluates the explanatory variables at the 90% confidence interval. To determine the percentage of time the true value of the explanatory variables falls within the specified range I use 90% confidence level intervals.

Urban Form Explanatory Variables

Street pattern

Five out of the six key explanatory variables for street pattern, ratio of street length to the number of homes, number of blocks, mean street length, block perimeter and the ratio of street

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[16] Correcting for heteroskedasticity causes the pool dummy variable to become significant.
[17] Correcting for heteroskedasticity causes the variable API score to become insignificant.

segments to intersections are significant at the 90% confidence level. The cul-de-sac dummy variable is not statistically significant. The expected positive sign for the number of blocks indicates that as the number of blocks in a neighborhood increases, home value increases all else being equal. The expected positive sign for mean street length indicates that as the linear amount of road in a neighborhood increases, home value increases all else being equal. The expected negative sign for block perimeter indicates that as the mean block perimeter increases across neighborhoods home value decreases all else being equal. Song and Knapp (2003) found similar results for block perimeter. The negative sign for the ratio of street segments to nodes is unexpected. The result indicates that as the ratio of streets segments to nodes increases (increased connectivity); home value decreases all else being equal. The negative sign for the ratio of street length to number of homes is also unexpected. This finding indicates that as the number of streets in a neighborhood increases home value decreases all else being equal. Song and Knapp (2003) found the opposite effect for both the ratio of streets segments to nodes and the ratio of street length to number of homes. The difference in results is likely due to omitted variable bias.[18]

Density

Housing unit density and population density are significant at the 99% confidence level. The unexpected positive sign for housing unit density indicates that as the housing unit density increases, home value increases all else being equal. Song and Knapp (2003) found the opposite effect for housing unit density. The expected negative sign for population density indicates that as population density increases home value decreases all else being equal. This finding is consistent with the result from Song and Knapp (2003). Immergluck and Smith (2006), Anderson and West (2002) however found population density to have the opposite effect.

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[18] This thesis controls for twice as many housing characteristics compared to the study by Song and Knapp (2003).

Land use mix

Land use entropy and non-residential land use entropy are significant at the 95% confidence level or greater. The expected positive sign for land use entropy indicates that homebuyers prefer homes in neighborhoods with a greater mix of residential, commercial, industrial, and open space land uses. As land use entropy increases, home value increases all else being equal. Song and Knapp (2003), Kockelman (1997) found land use entropy to have the opposite effect on home value. The difference in findings is likely due to the use of different land use categories used in their studies. For instance, Song and Knapp (2003) included additional categories e.g. multifamily in their land use entropy calculation.

Non-residential land use entropy, which had an uncertain effect, results in a negative relationship with home value. This result indicates that consumers prefer neighborhoods with less of a mix of commercial, industrial, and open space land uses. As non-residential land use entropy increases, home value decreases all else being equal. Song & Knapp (2003) found non-residential land use entropy to have a significant positive effect on home value. To my knowledge Song and Knapp (2003) is the only study to use non-residential land mix in estimating home value. As mentioned above the likely difference in the findings is due to the use of different land use categories used in their study.

Accessibility

Two of the variables, distance to central business district, and distance to light rail station, are significant at the 99% confidence level. Distance to commercial and distance to on-ramp are not statistically significant. The variables distance to light rail station and distance to CBD result in the expected direction. The negative sign for distance to the nearest light rail station indicates that as the distance to a light rail station increases home value decreases all else being equal. The result is consistent with findings by Hess and Almeida (2007) and Chen, Rufolo, and Dueker (1997). The negative sign for distance to CBD indicates that as the distance to the CBD increases home value decreases all else being equal. The result is consistent with findings by Troy and Grove (2008), Li and Brown (1980), Bowes and Ihlanfeldt (2001), and Downes and Zabel (1997).

Walkability

Only one of the three variables, home within 1400 feet of a park, is significant at the 99% confidence level. The variables, home within 1400 feet of a light rail stop, and home within 1400 feet of a commercial result in the expected direction, but are not statistically significant. The unexpected negative sign for the variable home within 1400 feet of a park indicate that parks are a disamenity rather than an amenity. The result indicates that homes located within walking distance of a park sell for a discount compared to homes beyond 1,400 feet from a park.

Housing variables

All thirteen housing variables are significant at the 99% confidence level.[19] Ten of the variables result in the expected direction. The effect of the remaining three variables, the number of bedrooms, CC&R regulations, and homeowner associations was uncertain. The results are consistent with findings from other studies.

The square footage of a home, the number of bedrooms, the number of full and half bathrooms, the number of garage space, the presence of a fireplace, the presence of a pool, and any type of remodel to a home has a positive effect on home value, all else being equal. In contrast, the age of the home, the presence of CC&R regulations, the presence of a homeowners association, the number of days the home is on the market, and if the home is bank owned, has a negative effect on home value, all else being equal.

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[19] The variable lot size is used as a weight to correct for heteroskedasticity, and therefore is not reported.

Neighborhood variables

Seven of the eight neighborhood variables are significant at the 99% confidence level. The variable API score is not statistically significant. Five of the variables, percent university degree, percent Black, percent Hispanic, percent owner occupied and poverty rate result in the expected direction. The percent of population with a university degree and percent owner occupied have a positive effect on home value, all else being equal. The expected negative sign for percent Black, percent Hispanic, and poverty rate indicate that minority and low income populations have a negative effect on home value, all else being equal. The uncertain effect of Asian population is found to have a positive effect on home value all else being equal. The unexpected negative sign for median household income indicates that income has a negative effect on home value.

Table 6: Corrected regression results

Variable Name	Corrected Model		Elasticity	90% level confidence interval		
	Est. Beta			Lower	Upper	VIF
(Constant)	11.6253170 (.077)	***				
Age	-.0042139 (.000)	***	-.4205	-0.004570	-0.003858	2.946
API score	-.0001047 (.000)		-.0105	-0.000220	0.000010	1.886
Number of full bathrooms	.0556094 (.009)	***	5.7185	0.040701	0.070518	3.423
Number of half bathrooms	.0261453 (.009)	***	2.6490	0.010814	0.041477	1.307
Number of bedrooms	.0179053 (.006)	***	1.8067	0.008177	0.027634	2.311
Number of blocks	1.0255633 (.119)	***	178.8666	0.829454	1.221673	6.466
Block perimeter	-.0209342	***	-2.0717	-0.027701	-0.014168	14.335

	(.004)					
CC&R dummy	-.0300861 (.008)	***	-2.9638	-0.043072	-0.017100	1.072
Cul-de-sac dummy	-.0176107 (.017)		-1.7457	-0.046097	0.010876	1.020
Distance to commercial	-.0000017 (.000)		-.0002	-0.000012	0.000008	3.308
Distance to CBD	-.0000051 (.000)	***	-.0005	-0.000006	-0.000004	3.558
Dist. to light rail station	-.0000056 (.000)	***	-.0006	-0.000007	-0.000004	1.801
Dist. to freeway onramp	.0000020 (.000)		.0002	-0.000001	0.000005	1.961
Days on market	-.0002511 (.000)	***	-.0251	-0.000332	-0.000170	1.052
Fireplace dummy	.1317922 (.008)	***	14.0871	0.118724	0.144861	1.451
Housing unit density	.0082627 (.002)	***	.8297	0.004980	0.011545	4.586
Homeowner association dummy	-.0548478 (.014)	***	-5.3371	-0.078507	-0.031189	1.797
Land use mix (entropy)	.0653463 (.028)	**	6.7529	0.020013	0.110679	3.710
Mean street length	.4936246 (.033)	***	63.8243	0.439550	0.547699	20.093
Household income	-.0000035 (.000)	***	-.0004	-0.000005	-0.000002	14.401
Number of garage spaces	.0706940 (.006)	***	7.3253	0.061611	0.079777	1.844
Non-res land use mix	-.0607667 (.018)	***	-5.8957	-0.090261	-0.031272	2.631
% Asian population	.0031439 (.001)	***	.3149	0.002307	0.003981	2.799
% bachelor’s degree	.0177621 (.001)	***	1.7921	0.016498	0.019026	11.487
% Black population	-.0060534 (.001)	***	-.6035	-0.006892	-0.005215	3.056

% Hispanic pop.	-.0067785 (.001)	***	-.6756	-0.007902	-0.005655	4.119
% owner occupied units	.0025779 (.001)	***	.2581	0.001712	0.003444	7.816
Poverty rate	-.0040135 (.001)	***	-.4005	-0.005381	-0.002646	9.086
Pool dummy	.0321828 (.012)	***	3.2706	0.012213	0.052152	1.098
Population density	-.0119712 (.002)	***	-1.1900	-0.015496	-0.008446	12.521
Home remodeled	.1344050 (.019)	***	14.3856	0.103703	0.165108	1.077
Real estate owned	-.2742582 (.008)	***	-23.9864	-0.287786	-0.260731	1.418
Square footage of home	.0003348 (.000)	***	.0335	0.000317	0.000352	4.197
Ratio of street length to # of homes	-2.5540801 (.192)	***	-92.2236	-2.870010	-2.238150	6.492
Street segments per intersections	-28.288513 (6.778)	***	-100.000	-39.43756	-17.13946	16.827
Walking distance of a commercial use	-.0017780 (.011)		-.1776	-0.019775	0.016219	3.011
Walking distance of a light rail stop	.0053416 (.015)		.5356	-0.018849	0.029532	1.180
Walking distance of a park	-.0217708 (.008)	***	-2.1536	-0.034699	-0.008843	1.507
R-squared	.787					
Observations	10052					

*Significant at the 90% confidence interval, ** Significant at the 95% confidence interval, *** Significant at the 99% confidence interval, (.000) Standard error, Elasticity= 100*(Exp(coefficient)-1), Confidence Interval = Coefficient +/- (Standard Error * Critical t-value), tc=1.645, 2-tailed test

Calculating the premium for New Urbanist characteristics

The results from the regression model make it possible to calculate the premium (or discount) for urban form characteristics. Remember I am interested in determining what affect urban form (street pattern, density, land use entropy, accessibility, and walkability), as a whole has on home value. Simply put, how does the design i.e. urban form of the neighborhood influence the value of the homes in that neighborhood while controlling for housing and neighborhood characteristics? Do homeowners pay a premium (or discount) for homes in neighborhoods with an urban form, which is characteristic of New Urbanism?

The first step of the premium calculation is to select two neighborhoods, one neighborhood with a suburban-style urban form and one with a New Urbanist-style urban form. What defines a suburban-style urban form and a New Urbanist-style urban form? A suburban style urban form has a less connected street pattern, larger block perimeters, less linear feet of streets, less mixed-use, less dense, less accessible, and less walkable. In contrast, a New Urbanist-style urban form has a more connected street pattern, smaller block perimeters, more linear feet of streets, more mixed-use, denser, more accessible, and more walkable. For example, a suburban-style urban form will have on average a larger block perimeter when compared to the average block perimeter of New Urbanist-style urban form. A suburban-style urban form and a New Urbanist-style urban from are essentially polar opposites in terms of their design.

To measure the premium (or discount) for New Urbanist characteristics, two neighborhoods i.e. census tracts, one with suburban characteristics and one with New Urbanist characteristics are chosen. To select the two neighborhoods I first created a table (see table D1 in the appendix) that contains the average values for all of the urban form characteristics across all neighborhoods. Next, I selected the top five urban form characteristics and the bottom five urban form characteristics most characteristic of the two neighborhood types. For example, the presence of smaller blocks in a neighborhood is a New Urbanist characteristic; therefore, I selected the top five neighborhoods with the lowest average block size. I used the same method to select neighborhoods with suburban characteristics. For example, the presence of large blocks is characteristic of suburban neighborhoods; therefore, I selected the bottom five neighborhoods with the highest average block size. Finally, I selected the neighborhood with the greatest number of characteristics matching a suburban-style urban form and the neighborhood with the greatest number of characteristics matching a New Urbanist-style urban form.

New Urbanist vs. Suburban neighborhood

Using the method described above I selected census tract 71 and census tract 13. Census tract 71 has an urban form that is most characteristic of a suburban style, and census tract 13 has an urban form that is most characteristic of a New Urbanist style. Figure 3 presents a context map showing the location of the two census tracts.

Located in the northwest part of the City of Sacramento, census tract 71 is most characteristic of a suburban neighborhood. Census tract 71 ranks in the top five for youngest housing stock, largest home size, lowest density, least amount of homes within walking distance to a park, the least number of blocks, the least linear feet of street, and the least number of streets per intersection. Figure 4 provides a map of the census tract, an aerial view, and an image of a typical home found in the census tract.

Figure 3: Map of City of Sacramento

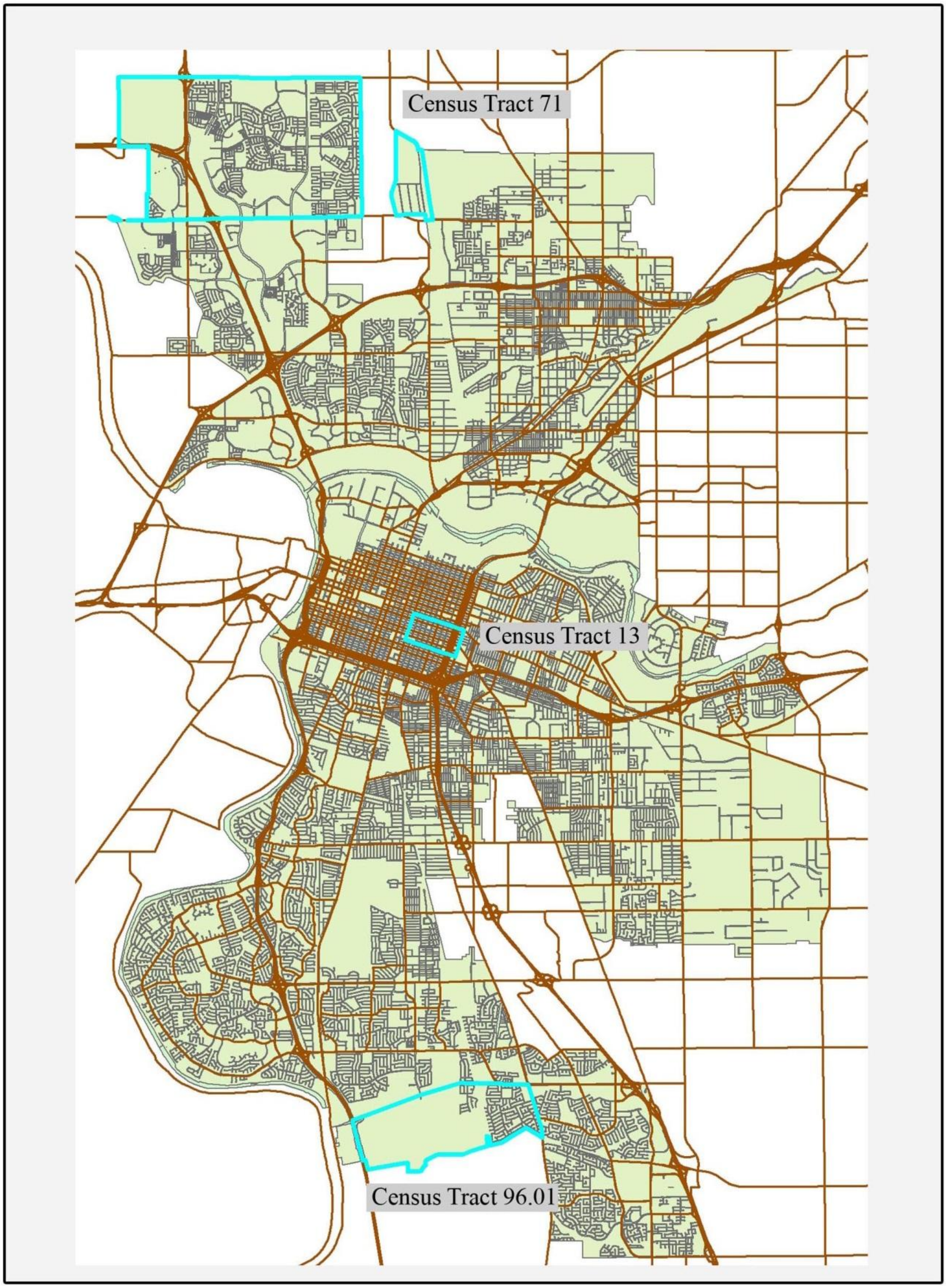
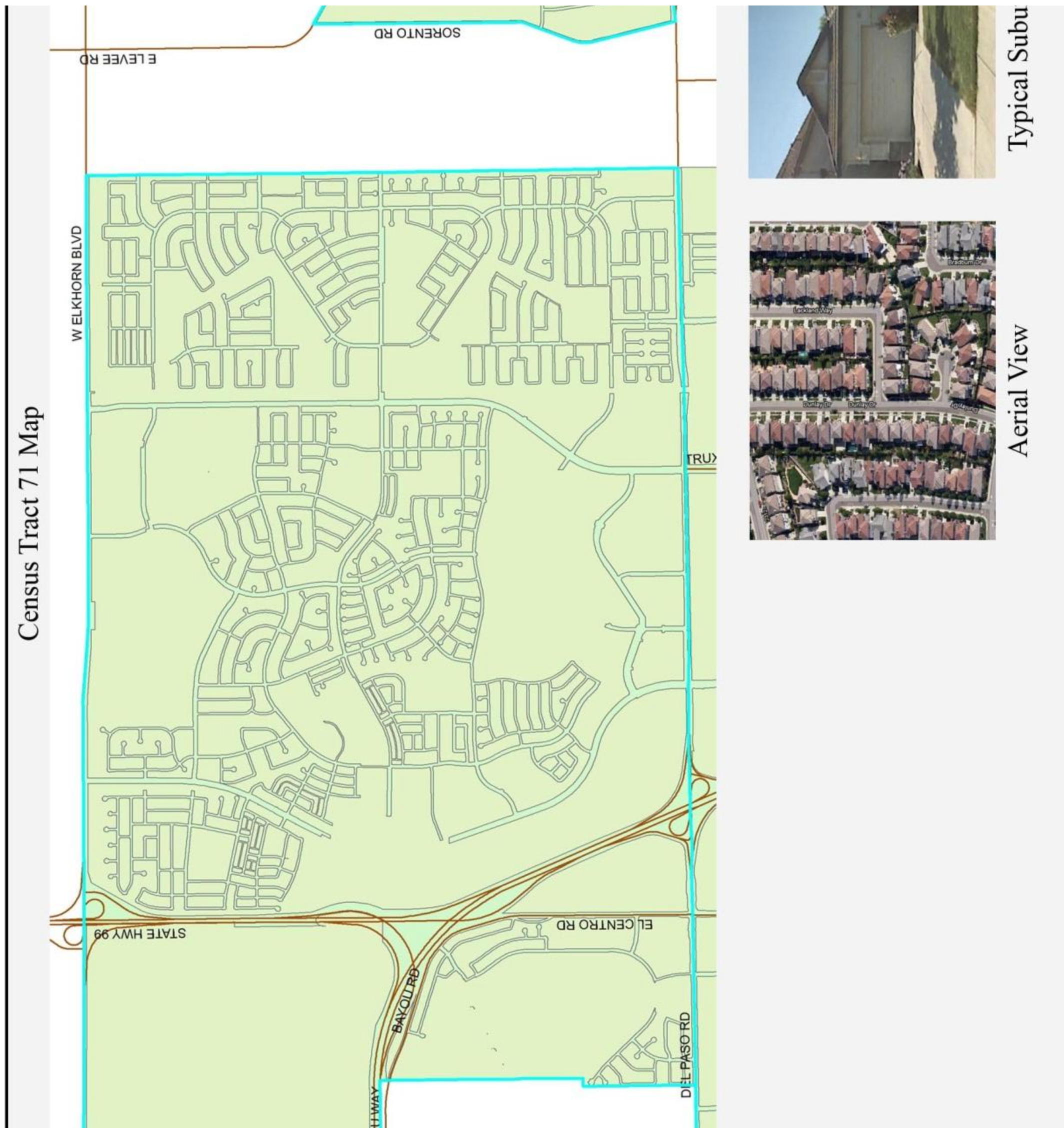
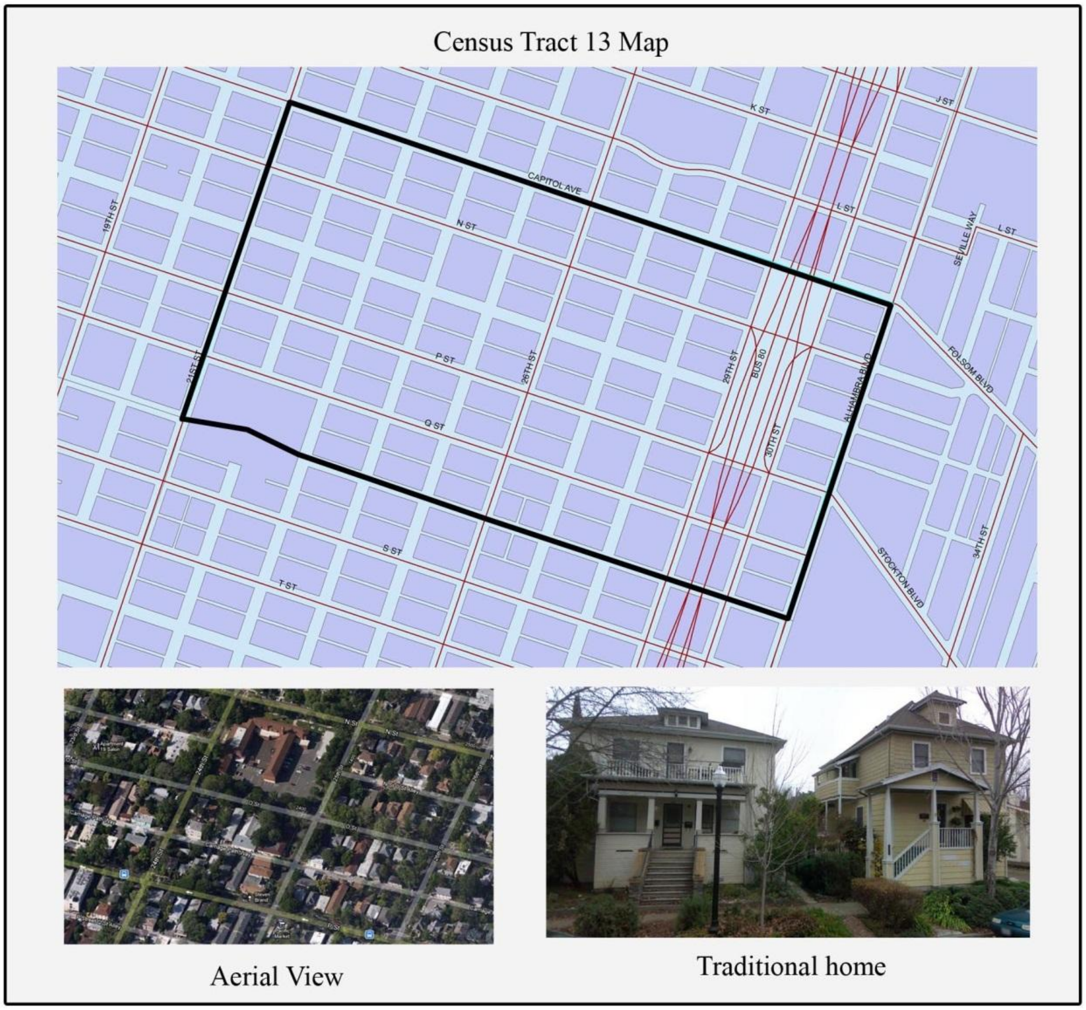


Figure 4: Census tract 71



Located in the center of Sacramento, census tract 13 is the most characteristic of a New Urbanist-style urban form. Census tract 13 ranks in the top five for highest density, the greatest accessibility (to CBD, commercial uses, and light rail station), the greatest number of homes within walking distance to commercial uses and light rail stations, the greatest number of blocks, the smallest block perimeter, and the greatest number of streets per intersections. Figure 5 provides a map of the census tract, an aerial view, and an image of a typical home found in the census tract.

Figure 5: Census tract 13



Premium calculation walkthrough

With the selection of the suburban neighborhood (CT 71) and the New Urbanist neighborhood (CT 13), it is now possible to calculate the premium (or discount) for New Urbanist characteristics.[20] The first step is to calculate the premium or discount for an average priced single-family home located in the city of Sacramento. Next, I calculate the sale price for both, a home in a neighborhood with suburban characteristics and a home in a neighborhood with New Urbanist characteristics, while holding constant all other urban form characteristics. Third, I calculate the overall sale price for a home in a typical suburban neighborhood and the sale price for a home in a neighborhood with New Urbanist characteristics. Lastly, I calculate the individual marginal price premium homebuyers pay for urban form characteristics. Table 7: Premium estimation results CT 13 & 71 presents the information described in the following paragraphs.

To determine the premium (or discount) for an average priced single family home located anywhere in Sacramento; the first step is to calculate the exponent of the beta coefficients (EXP (β)) for all urban form variables (column 2). Next, is to multiply the exponent of the betas minus one by the average home value in the city of Sacramento (EXP β_1-1)*129,000. The median price of a single-family home in Sacramento in the first quarter of 2011 is $129,000 (Trulia.com). Column 3 represents the price premium (or discount), that is the change from X_1 to (X_1+1) while holding constant all other urban form characteristics. For instance, homebuyers will pay a $1,070 price premium for a home in a neighborhood with greater housing unit density, all else being equal.

Next, is to calculate the sale price for both, a home in a neighborhood with a suburban-style urban form and a home in a neighborhood with a New Urbanist- style urban form, while holding constant all other urban form characteristics. Following the same procedure for step one, the sale price is calculated by [EXP (β_0+ $\beta_i X_i$)] (column 5 and 7). For example, when considering

[20] The method used here to calculate the premium for New Urbanist characteristics is similar to the method used by Song and Knapp (2003).

location to the CBD, the sale price for a home in a suburban neighborhood is $93,260, versus $108,733 for a home in a New Urbanist-style neighborhood, all else being equal.

The third step is to calculate the overall sale price for a home in a neighborhood with a suburban-style urban form and the sale price for a home in a neighborhood with a New Urbanist-style urban form. I compute the sale price by taking the average value of all the individual sale prices (column 5 and 7) based on each individual urban form characteristics. The overall sale price for a home in a neighborhood with a suburban-style urban form is $116,517 (bottom row). The overall sale price for a home in a neighborhood with a New Urbanist-style urban form is $122,500 (bottom row).

Lastly, I compute the marginal price premium homebuyers are willing to pay for a New Urbanist-style urban form. The marginal price premium is the change in the price of a home in a suburban neighborhood which results from a one characteristic change in urban form, from suburban urban form (column 4) to New Urbanist urban form (column 6). The marginal price premium is calculated by [EXP β (X_1NU-X_1Sub)-1]* 116,799. For example, the price premium for a home in a neighborhood with a New Urbanist-style street pattern is $3,200.

The estimated sale price, calculated in step three reveal that a typical single-family home in neighborhood (CT 13) with a New Urbanist-style urban form sells for $121,989, while a typical single-family home in a neighborhood (CT 71) with a suburban-style urban form sells for $116,799. This amounts to a difference of $5,189 in sale price or a 4.25% premium for a New Urbanist-style urban form.

Table 7: Premium estimation results CT 13 & 71

Variable	e β	Premium (129,000)	Suburban Neighborhood	NU Neighborhood	Premium for NU Neighborhood
Intercept	111895.092		11.625	11.625	

Number of blocks	2.788666	$230,737.90	.0117	.4423	$64,851
Block perimeter	0.979283	-$2,672.44	.0868	5.2058	-$11,869
Cul-de-sac dummy	0.982543	-$2,251.89	.0403	.0000	$83
Distance to commercial	0.999998	-$0.21	1373.0580	346.7627	$198
Distance to CBD	0.999995	-$0.65	35964.1949	5670.0727	$19,329
Table 7 continued	e β	Premium (129,000)	Suburban Neighborhood	NU Neighborhood	Premium for NU Neighborhood
Distance to light rail station	0.999994	-$0.72	5116.4596	1532.6727	$2,359
Distance to freeway onramp	1.000002	$0.26	5818.0583	1244.7747	-$1,053
Housing unit density	1.008297	$1,070.31	.2000	32.1700	$35,313
Land use mix	1.067529	$8,711.19	.6700	.7500	$612
Mean street length	1.638243	$82,333.40	.0162	1.4486	$120,075
Non-residential land use mix	0.941043	-$7,605.48	.5700	.7300	-$1,130
Population density	0.988100	-$1,535.07	.0400	16.3900	-$20,763
Ratio of street length to # of homes	0.077764	-$118,968	.0505	.1281	-$20,997
Ratio of street segments to intersections	0.000000	-$129,000	.0001	.0094	-$26,963
Home within 1400 feet of commercial service	0.998224	-$229.15	.5857	1.0000	-$86

Home within 1400 feet of a light rail stop	1.005356	$690.91	.0319	.4667	$272
Home within 1400 feet of a park	0.978464	-$2,778.08	.0017	.9333	-$2,345
Square footage	1.000335	$43.20	2179.6210	1292.1333	-$30,026
		Home price			
	Suburban		New Urbanist	Difference	Premium
	$116,799		$121,989	$5,189	4.25%

In addition, I compare census tract 96.01 located in south Sacramento to census tract 13, using the same method to calculate the premium (or discount) for New Urbanist characteristics (see Table 8: Premium estimation results CT 13 & 96.01).[21] The overall estimated sale price for a home in CT 96.01 (with a suburban-style urban form) is $114,323. The overall estimated sale price for census tract 13 remains unchanged ($121,988). This amounts to a difference of $7,665 in sale price or a 6.28% premium for New Urbanist-style urban form. The findings revel that homes in neighborhoods with New Urbanist characteristics sell for a premium when compared to homes located in a typical suburban neighborhood.

[21] Census tract 96.01 is in the top five CT's that exhibit suburban characteristics.

Table 8: Premium estimation results CT 13 & 96.01

Variable	e β	Premium (129,000)	Suburban Neighborhood	NU Neighborhood	Premium for NU Neighborhood
Intercept	111895.09		11.625	11.625	
Number of blocks	2.788666	$230,737.90	.0249	.4423	$61,087
Block perimeter	0.979283	-$2,672.44	1.4166	5.2058	-$8,718
Cul-de-sac dummy	0.982543	-$2,251.89	.0803	.0000	$162
Distance to commercial	0.999998	-$0.21	2276.1023	346.7627	$365
Distance to CBD	0.999995	-$0.65	40272.6264	5670.0727	$21,853
Distance to light rail station	0.999994	-$0.72	2664.5216	1532.6727	$724
Distance to freeway onramp	1.000002	$0.26	8921.3229	1244.7747	-$1,725
Housing unit density	1.008297	$1,070.31	1.4300	32.1700	$33,059
Land use mix	1.067529	$8,711.19	.7100	.7500	$299
Mean street length	1.638243	$82,333.40	.1968	1.4486	$97,758
Non-residential land use mix	0.941043	-$7,605.48	.7800	.7300	$348
Population density	0.988100	-$1,535.07	3.8000	16.3900	-$15,995
Ratio of street length to # of homes	0.077764	-$118,968	.0257	.1281	-$26,303
Ratio of street segments to intersections	0.000000	-$129,000	.0010	.0094	-$24,174
Home within 1400 feet of commercial service	0.998224	-$229.15	.2249	1.0000	-$157

Home within 1400 feet of a light rail stop	1.005356	$690.91	.1446	.4667	$197
Home within 1400 feet of a park	0.978464	-$2,778.08	.8554	.9333	-$194
Square footage	1.000335	$43.20	1448.2450	1292.1333	-$5,822
		Home Price			
	Suburban		New Urbanist	Difference	Premium
	$114,324		$121,989	$7,665	6.28%

Chapter 5

CONCLUSION

Introduction

This chapter serves as the conclusion to this thesis. First, a summary of the information in this thesis is presented. Next, the implications of the findings are discussed, followed by a discussion of the possible limitations and flaws. Last of all is a discussion of opportunities for future research.

Summary

Population growth, changing demographic trends and housing preferences are influencing growth patterns in California. Research shows a shift away from growth in suburban development to a shift towards development patterns that are more characteristic of New Urbanism. On one hand, suburban neighborhoods tend to be less dense, less connected (internally and externally), exhibit less accessibility (greater distance) to jobs and private and public services, and are less walkable. On the other hand, neighborhoods with a New Urbanist-style urban form are denser, more connected (internally and externally), have greater accessibility to jobs and private and public services, and are more walkable.

Research shows that there is a significant difference between a suburban-style urban form and a New Urbanist-style urban form. These studies reveal that urban form can be disaggregated into quantifiable components (e.g. density, street pattern, land use mix, accessibility, and walkability). Moreover, hedonic regression can be used to measure the price effect that urban form components have on home value. This thesis attempts to determine whether urban form significantly affects home value, and if so, does a New Urbanist-style urban form command a premium (or discount) over that of a suburban-style urban form?

Based on these previous studies, I estimate a hedonic model to analyze the effect that urban form characteristics has on home values in the City of Sacramento. After controlling for structural characteristics and neighborhood characteristics, I hypothesize that street pattern, density, land use mix, accessibility, and walkability are five broad categories that influence home value. Data for 10,052 individual sales transactions within the City of Sacramento are collected and aggregated at the census tract level. I created Seventeen variables that proxy for urban form. In addition to the urban form variables, thirteen variables proxy for structural characteristics and eight variables proxy for neighborhood characteristics.

The hedonic model explains 79% of the variation in the home values in the sample. The results reveal that urban form characteristics significantly affect home value in different ways. Holding other factors that influence home value constant, the number of blocks, the size of blocks, proximity to cul-de-sacs, accessibility (to commercial services, CBD, and light rail stations), housing unit density, land use mix, the linear amount of street, and the ability to walk to light rail command a price premium. On the other hand, the proximity to an on-ramp, non-residential land use mix, population density, the ratio of streets to homes, walkability to commercial services and parks discount home value. These findings clearly indicate that the design of urban form is important to homebuyers.

Further analysis of the estimated premium for New Urbanist characteristics, reveal homes located in neighborhoods with a New Urbanist-style urban form sell for a 4.88% premium compared to homes located in a typical suburban neighborhood. These findings reveal that homebuyers will pay a premium for homes in neighborhoods that have a New Urbanist-style urban form, i.e. more blocks, smaller blocks, accessible to commercial services, job centers, and light rail stations, are denser, and mixed-use. This indicates, based on the sample, that there is a measurable preference for New Urbanist-style urban form.

Implications

While the findings of this thesis are specific to the city of Sacramento, the implications of the findings are far-reaching. Homeowners and advocates of New Urbanism and, to a lesser extent, developers alike will find the information contained in this thesis insightful and applicable to their professions.

Homeowners

The findings from this thesis should be of particular interest to current and future homeowners. Since 2005, according to data from Zillow.com, average home values in the city of Sacramento have plummeted by more than 55% from a high of $357,000 (2005) to a low of $150,000 as of July 2011. However, not all areas of Sacramento exhibited the same decline in home values. Two areas of Sacramento that closely resemble a New Urbanist-style urban form are ZIP codes 95816 and 95819.[22] Home values in these areas on average only dropped by 31% from a high in the mid-$450,000s in September 2005 to $310,000 in July 2011. Conversely, ZIP codes 95835 and 95823,[23] which closely resemble a suburban style urban form, experienced a drop of more than 61% in home values over the same time. Home values in these areas on average ranged from the mid-$360,000s in September 2005 to the mid-$130,000s in July 2011.

Sacramento homeowners on average have lost more than half of the equity in their homes since 2005. The implication to homeowners and future homebuyers, at least in the city of

[22] In this example, census tract level data is preferred to ZIP code level data; however, census tract data is not available. I chose these specific ZIP codes because census tract 13, used in the premium calculation, is within ZIP code 95816 and borders ZIP code 95819.

[23]Likewise, I chose ZIP code 95835 and 95823 because census tract 71 and census tract 96.01 respectively are located within the ZIP codes.

Sacramento, is that a home in a neighborhood with New Urbanist-style urban form commands a premium and is therefore more valuable than a home in a suburban-style neighborhood, all else being equal. Moreover, the example above demonstrates that homes in a neighborhood with a New Urbanist-style urban form hold their value better than homes in neighborhoods with a suburban-style urban form.

New Urbanism

In an effort to provide an alternative to suburban development, New Urbanists advocate for compact, mixed-use, walkable neighborhoods. New Urbanists argue that suburban design causes numerous negative externalities that are not paid for by homeowners. By designing compact, mixed-use, walkable neighborhoods, New Urbanists claim, many of these negative externalities can be reduced or eliminated. Based on the findings presented here, there is clear evidence to support the New Urbanist design ideology. New Urbanists can use this information to further their advocacy for a shift away from the suburban development pattern.

Flaws and Limitations

Potential flaws and limitations are an inherent fact for all regression-based studies. Flaws and limitations associated with this thesis include, but are not limited to: 1) measuring urban form characteristics, 2) issues with spatial effects related to spatial data, and 3) price premium calculation and neighborhood selection.

While an extensive amount of time was spent reviewing scholarly articles and books on topics related to New Urbanism, little information could be found on the best way to quantitatively measure urban form. Numerous studies have analyzed individual characteristics of urban form separately but not as a whole. To my knowledge, Song and Knapp (2003) is the only regression-based study to analyze urban form as a whole and measure its effect on home value.

Song and Knapp (2003) provided much of the background information and methodology for this thesis. Therefore, the lack of support from additional studies poses major limitations to the findings.

Not correcting for the spatial effects (e.g. spatial autocorrelation) associated with the data set is another possible flaw. Preliminary analysis of the Moran's I coefficient (0.271) using both GeoDa™ and ArcMap™ 10 indicate that there is evidence of significant spatial autocorrelation associated with the data set. Potential flaws in parameter estimates and statistical significance tests can result if spatial autocorrelation is not corrected for in hedonic analysis (De Knegt, 2010). In simple terms, if autocorrelation is corrected for, there is a higher chance that the estimated model will have greater accuracy than a model that does not correct for autocorrelation. In a study by Troy and Grove (2008), the authors compared a non-spatial model and a spatial model and found no significant difference in parameter estimates between the two models. Whether this would affect the findings of this thesis is undetermined.

The third potential flaw is the method of selecting neighborhoods to make comparisons of the price premium for New Urbanist characteristics. Although the findings from the premium calculations for New Urbanist characteristics are consistent with the findings by Song and Knapp (2003), the method of selecting the two neighborhoods is debatable. Recall that, to measure the premium (or discount) for New Urbanist-style urban form, I chose two neighborhoods, i.e. census tracts, one with suburban characteristics and one with New Urbanist characteristics. A selection matrix (see appendix C1) was created that contains the average values for all urban form characteristics. The average statistics for all urban form characteristics, for all 88 neighborhoods, were compared to determine which neighborhoods were most characteristic of a suburban neighborhood and most characteristic of a New Urbanist-type neighborhood.

Song and Knapp (2003) compared a hypothetical suburban neighborhood (based on the mean values for their sample) to that of an actual New Urbanist project (Orenco Station). Sacramento does not have any specific "New Urbanist" projects. The selection of the two census tracts for comparison purposes is based on the census tract's urban form characteristics. To my knowledge, no other study has employed this method of selection. It is entirely possible that the price difference is due to location alone[24]. Without the ability to analyze a true New Urbanist neighborhood, any conclusions about marginal effects and total price difference for New Urbanist characteristics are subject to scrutiny.

Future research

The flaws and limitations associated with this thesis present opportunity for future research. The following is a list of ways to expand on this thesis and the broader body of knowledge related to urban form and home value.

1. Develop and improve upon the quantitative measures of urban form. For example, there might be a better measure for measuring mixed-use neighborhood characteristics rather than land-use entropy. Other urban form elements might include sidewalk design, landscape and vegetation quality, parking design, etc.
2. Use census blocks instead of census tracts in order to capture finer distinctions between neighborhoods.
3. Improve accuracy of regression results by correcting for spatial heterogeneity and spatial autocorrelation.

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[24] Premium calculations were based on average value for all neighborhood characteristics and were aggregated at the census tract level. The use of locational dummy variables, if used in the model, would have no effect on the premium calculation.

4. Improve upon GIS-derived measurements. For instance, use network distance measurement rather than straight-line distance measurements to make distance measure more accurate.
5. Update the demographic data with information drawn from the 2010 Census.

APPENDIX

Table 1A: Urban Form Literature Review Table

Source	Specification	
Song & Knapp (2003)	Log-Lin	
Variable (s)	Sig/ (Beta)	Magnitude of Effect
Internal connectedness	Sig (0.04468)	For every 1-unit increase in internal connectedness, home value increases by 4.5%.
Streets/homes	Sig (0.00033)	For every 1-unit increase in streets/homes, home value increases by 0.03%.
Blocks/homes	Sig (0.14644)	For every 1-unit increase in blocks/homes, home value increases by 14.6%.
Block size	Sig/ Neg	As block size increases, home value decreases.
Cul-de-sac	Sig (0.00116)	Homes w/in 50' of a cul-de-sac are valued 0.012% more than homes located elsewhere.
Length of cul-de-sac	Sig (−0.00011)	For every 1-unit increase in the length of cul-de-sacs, home value decreases by 0.01%.
External connectedness	Sig (0.00008)	For every 1-unit increase in external connectedness, home value increases by 0.008%.
Housing unit density	Sig (−0.00110)	For every 1-unit increase in housing unit density, home value decreases by 0.11%.
Population density	Sig (−0.00863)	For every 1-unit increase in population density, home value decreases by 0.863%.
Land use mix	Sig (−0.04706)	For every 1-unit increase in the land use mix, home value decreases by 4.7%.
Non-residential LU mix	Sig (0.01401)	For every 1-unit increase in the non-residential land use mix, home value increases by 1.4%.
Commercial distance	Sig (0.00001)	For every 1-unit increase in the distance to commercial use, home value increases by 0.001%.
Bus stop distance	NS	No significant effect
Park distance	Sig (−0.00001)	As distance to the nearest park increases, home value decreases by 0.001%.
PortCBD	Sig (−0.00001)	For every 1-unit increase in the distance from the Portland CBD, home value decreases by 0.001%.
HillCBD	Sig/ Neg	No significant effect
Source	Specification	
Song & Knapp (2003)cont.	Log-Lin	
Variable (s)	Sig/ (Beta)	Magnitude of Effect
BeavCBD	Sig (0.00001)	For every 1-unit increase in the distance from the Beaverton CBD, home value increases by 0.001%.
Distance to	Sig (−0.0002)	For every 1-unit increase in the distance to a minor road,

Minor road		home value decreases by 0.021%.
On major road	Sig (−0.0389)	Homes located on a major road sell for a 4% discount compared to homes not located on a major road.
On light rail	Sig (−0.0458)	Homes located within 500 feet of a light rail line sell for a 4.6% discount compared to homes not located near a light rail line.
Light rail station	Sig (+/-)	Mixed results
% Homes w/in 0.25 mile of Commercial	Sig (0.05525)	For every 1-unit increase in % Homes w/in 0.25 mile of Commercial, home value increases by 0.055%.
% Homes w/in 0.25 mile of a Bus stop	Sig (−0.00607)	For every 1-unit increase in % Homes w/in 0.25 mile of a bus stop, home value increases by 0.0061%.
Source	Specification	
Guttery (2002)	Log-semi	
Variable (s)	Sig/ (Beta)	Magnitude of Effect
Alleyways	Sig (-0.054)	Homes located on alleyways are discounted 5.4% compared to other homes not located on alleyways.
Source	Specification	
Asabere (1990)	Log-semi	
Variable (s)	Sig/ (Beta)	Magnitude of Effect
Cul-de-sacs	Sig (0.251)	Homes located on cul-de-sacs sell for a 25% price premium compared to homes not located on cul-de-sacs.
Source	Specification	
Troy and Grove (2008)	Log-Lin	
Variable (s)	Sig/ (Beta)	Magnitude of Effect
Distance to park	Sig (−0.021717)	For every 1-unit increase in distance from the nearest park, home value decreases by 2.2%
distance to CBD	Sig (−0.148374)	For every 1-unit increase in distance from the CBD, home value decreases by 14.8%
Distance to interstate on-ramp	Sig (−0.019359)	For every 1-unit increase in distance to the nearest interstate on-ramp, home value decreases by 1.9%.
Source	Specification	
Cao & Cory (1981)	Linear	
Variable (s)	Sig/ (Beta)	Magnitude of Effect
Distance to nearest employment center	Sig/ Neg	As the distance to nearest employment center increases, home value significantly decreases.
Employment/ housing units	Sig/ Pos	As the ratio of employment to housing units increases, home value significantly increases.
Multi-family	Sig/ Pos	As the proportion of multi-family land use increases,

land use		home value significantly increases.
Commercial land uses	Sig/ Pos	As the proportion of commercial land uses increases, home value significantly increases.
Industrial land uses	Sig/ Pos	As the proportion of industrial land uses increases, home value significantly increases.
Source	Specification	
Li & Brown (1980)	Linear-semi	
Variable (s)	Sig/ (Beta)	Magnitude of Effect
Residential density	NS	No significant effect
Distance to the Boston CBD	Sig (-186)	For every 1-unit increase in the distance from the CBD, home value decreases by $186
Distance to Major road (log)	Sig (1,170)	For every 1% increase in distance to a major road home value increases by $1170
Distance to commercial (log)	Sig (-1,486)	For every 1% increase in the distance to commercial use, home value decreases by $1486
Distance to industrial (log)	Sig (-1,366)	For every 1% increase in distance to Industrial use home value decreases by $1,366
		Table continued on next page
Source	Specification	
Clark & Herrin (2000)	Log-lin	
Variable (s)	Sig/ (Beta)	Magnitude of Effect
Population density	NS	No significant effect
Source	Specification	
Bowes and Ihlanfeldt (2001)	Log-Semi	
Variable (s)	Sig/ (Beta)	Magnitude of Effect
Distance to CBD	Sig (-0.024)	For every 1-unit increase in distance from the CBD, home value decreases by 2.4%.
Highway distance	NS	No significant effect
Light rail station	Sig (-0.187)	Homes w/in 0.25 miles of a light rail station are valued 18.7% less than homes located beyond a quarter-mile.
Source	Specification	
Hess and Almeida (2006)	Linear	
Variable (s)	Sig/ (Beta)	Magnitude of Effect
LR stop Straight-line distance	Sig (-2.31)	For every 1-unit increase in the straight-line distance from a LR stop, home value decreases by $2.30.
LR stop network distance	Sig (-0.99)	For every 1-unit increase in the network distance from a LR stop, home value decreases by $0.99.

Distance to CBD	Sig (0.36)	For every 1-unit increase in the distance from the CBD, home value increases by $0.36.
Distance to park	Sig (0.32)	For every 1-unit increase in the distance from the nearest park, home value increases by $0.32.
		Table continued on next page
Source	Specification	
Chen, Rufolo, & Dueker (1997)	Log-Semi	
Variable (s)	Sig/ (Beta)	Magnitude of Effect
Distance to LR line	NS	No significant effect
Distance to nearest LR station	Sig (-1.49524E-04)	For every 1-unit increase in the distance from the nearest LRT station, home values decrease by 0.01%.
Distance to park	NS	No significant effect
Source	Specification	
Jud (1980)	Log-Semi	
Variable (s)	Sig/ (Beta)	Magnitude of Effect
Residential	Sig (0.11)	Homes located on residential zoned land sell for a 11% price premium compared to homes not located on residential zoned land.
Commercial	Sig (-0.013)	For every 1-unit increase in the proportion of commercial land use, home value decrease by 1.3%.
Industrial	Sig (0.025)	For every 1-unit increase in the proportion of industrial land use, home value increase by 2.5%.
Vacant	NS	No significant effect
Distance to employment center	NS	No significant effect
Source	Specification	
Kestens…& Rosiers (2006)	Log-Semi	
Variable (s)	Sig/ (Beta)	Magnitude of Effect
Car time to MACs	Sig (-0.0250)	For every 1-unit increase in travel time to main activity center, home value decreases by 2.5%.
Highway exit	Sig (0.0090)	For every 1-unit increase in travel time to the nearest highway exit, home value decreases by 0.9%.
		Table continued on next page
Source	Specification	
Downes and	Log-Semi	

Zabel (1997)		
Variable (s)	Sig/ (Beta)	Magnitude of Effect
Distance to CBD	Sig (-0.0047)	For every 1-unit increase in the distance from the CBD, home value decrease by 0.47%.

Table 2B: Housing Variables Literature Review Table

Source/ Location	Specification	
Song & Knapp (2003)	Log-Lin	
Variables	Sig/ Beta	Magnitude of Effect
Lot size	Sig (0.00001)	For every 1-unit increase in lot size, home value increases by 0.001%.
Sq. footage	Sig (0.00031)	For every 1-unit increase in square footage, home value increases by 0.031%.
Age	Sig (−0.00775)	For every 1-unit increase in age, home value decreases by 0.78%.
On water	NS	No significant effect
Mountain view	Sig (0.06123)	Homes with a mountain view sell for a 6.1% premium compared to homes without a mountain view.
Source/ Location	Specification	
Guttery (2002)	Log-log	
Variables	Sig/ Beta	Magnitude of Effect
Living area-log	Sig (0.806)	For every 1 % increase in living area, home value increases by 0.81%.
Age-log	Sig (-0.079)	For every 1 % increase in age, home value decreases by 0.079%.
Net area-log	Sig (0.031)	For every 1 % increase in net area, home value increases by 0.031%.
# of Bedrooms-log	NS	No significant effect
# of Bathrooms-log	Sig (0.281)	For every 1 % increase in the # of bathrooms, home value increases by 0.28%.
Lot size-log	Sig (0.106)	For every 1 % increase in lot size, home value increases by 0.11%.
Source/ Location	Specification	
Asabere (1990)	Log-semi	
Variables	Sig/ Beta	Magnitude of Effect
Lot size-log	Sig (0.154)	For every 1 % increase in lot size, home value increases by 0.15%.
Sq. footage-log	Sig (0.023)	For every 1 % increase in sq' footage, home value increases by 0.023%.
# of Rooms	Sig (0.061)	For every 1-unit increase in the # of rooms, home

		value increases by 6.1%.
# of Bathrooms	Sig (0.089)	For every 1-unit increase in the # of bathrooms, home value increases by 8.9%.
# of Bedrooms	Sig (0.062)	For every 1-unit increase in the # of bedrooms, home value increases by 6.2%.
Age	Sig (-0.0063)	For every 1-unit increase in age, home value decreases by 0.63%.
Source/ Location	Specification	
Troy and Grove (2008)	Log-semi	
Variables	Sig/ Beta	Magnitude of Effect
Sq. footage-log	Sig (0.313910)	For every 1 % increase in sq' footage, home value increases by 0.31%.
Lot size	Sig (0.000060)	For every 1-unit increase in lot size, home value increases by 0.006%
# of Bathrooms	Sig (0.054814)	For every 1-unit increase in the # of bathrooms, home value increases by 5.4%
Age	Sig (−0.001502)	For every 1-unit increase in age, home value decreases by 0.15%
Source/ Location	Specification	
Li & Brown (1980)	Linear	
Variables	Sig/ Beta	Magnitude of Effect
# of Rooms	Sig (3,702)	For every 1-unit increase in the # of rooms, home value increases by $3,700.
# of Bathrooms	Sig (6,026)	For every 1-unit increase in the # of bathrooms, home value increases by $6,000.
Age	Sig (-134)	For every 1-unit increase in the age, home value decreases by $134.
# of garage spaces	Sig (1,921)	For every 1-unit increase in the # of garage, spaces home value increases by $1,900.
# of fireplaces	Sig (940)	For every 1-unit increase in the # of fireplaces, home value increases by $940.
Basement	Sig (2,612)	Homes with a basement sell for $2,600 more compared to homes w/o a basement.
Lot size	Sig (114)	For every 1-unit increase in the lot size, home value increases by $114.
Patio	Sig (2,090)	Homes with a patio sell for $2,100 more compared to homes w/o a patio.
Source/ Location	Specification	
Clark & Herrin (2000)	Log-lin	
Variables	Sig/ Beta	Magnitude of Effect
# of bedrooms	Sig (-0.018)	For every 1-unit increase in the # of bedrooms, home value decreases by 1.8%.

# of fireplaces	Sig (0.054)	For every 1-unit increase in the # of fireplaces, home value increases by 5.4%.
# of full bathrooms	Sig (0.035)	For every 1-unit increase in the # of full bathrooms, home value increases by 3.5%.
# of half Bathrooms	Sig (0.022)	For every 1-unit increase in the # of half bathrooms, home value increases by 2.2%.
Lot size	Sig (0.00000144)	For every 1-unit increase in lot size, home value increases by 0.00016%.
Sq. footage	Sig (0.0005)	For every 1-unit increase in sq' footage, home value increases by 0.05%.
Age	Sig (-0.006)	For every 1-unit increase in age, home value decreases by 0.6%.
Source/ Location	Specification	
Bowes and Ihlanfeldt (2001)	Log-lin	
Variables	Sig/ Beta	Magnitude of Effect
# of Bedrooms	Sig (0.099)	For every 1-unit increase in the # of bedrooms, home value decreases by 10%.
# of Bathrooms	Sig (0.176)	For every 1-unit increase in the # of bathrooms, home value increases by 18%.
Lot size	Sig (0.001)	For every 1-unit increase in lot size, home value increases by 0.1%.
Age	Sig (-0.005)	For every 1-unit increase in age, home value decreases by 0.5%.
# of fireplaces	Sig (0.145)	For every 1-unit increase in the # of fireplaces, home value increases by 14.5%.
Basement	Sig (0.120)	Homes with a basement sell for a 12% premium compared to homes w/o a basement.
Source/ Location	Specification	
Hess and Almeida (2006)	Linear	
Variables	Sig/ Beta	Magnitude of Effect
Age	Sig (-33.97)	For every 1-unit increase in age, home value decreases by $34.
# of bathrooms	Sig (25054.33)	For every 1-unit increase in the # of bathrooms, home value increases by $25,000.
Lot size	Sig (4.09)	For every 1-unit increase in lot size, home value increases by $4.
# of fireplaces	Sig (16178.64)	For every 1-unit increase in lot size, home value increases by $16,200.
Basement	Sig (7445.44)	Homes with a basement sell for $7,400 more than homes w/o a basement.
Source/ Location	Specification	
Chen, Rufolo, & Dueker (1997)	Log-Semi	

Variables	Sig/ Beta	Magnitude of Effect
Age	Sig (-0.00204)	For every 1-unit increase in age, home value decreases by 0.2%.
Lot size	NS	No significant effect
House size	Sig (2.36795E-04)	For every 1-unit increase in house size, home value increases by 0.024%.
# of Bedrooms	Sig (0.021725)	For every 1-unit increase in the # of bedrooms, home value decreases by 2.2%.
# of Bathrooms	Sig (0.024202)	For every 1-unit increase in the # of bathrooms, home value increases by 2.4%.
# of fireplaces	Sig (0.032279)	For every 1-unit increase in the # of fireplaces, home value increases by 3.2%.
Basement	Sig (0.065506)	Homes with a basement sell for a 6.6% premium compared to homes w/o a basement.
Attached garage	Sig (0.041541)	Homes with an attached garage sell for a 4.2% premium compared to homes w/o an attached garage.
Source/ Location	Specification	
Jud (1980)	Log-Semi	
Variables	Sig/ Beta	Magnitude of Effect
Age	Sig (-0.008)	For every 1-unit increase in age, home value decreases by 0.8%.
Air conditioning	Sig (0.035)	Homes with a AC sell for a 3.5% premium compared to homes w/o AC.
Fireplace	Sig (0.044)	Homes with a fireplace sell for a 4.4% premium compared to homes w/o a fireplace.
Brick veneer	Sig (0.085)	Homes with a brick veneer sell for an 8.5% premium compared to homes w/o brick veneer.
# of Stories	NS	No significant effect
Source/ Location	Specification	
Kesten & Rosiers (2006)	Log-Semi	
Variables	Sig/ Beta	Magnitude of Effect
Living area	Sig (0.0042)	For every 1-unit increase in the living area, home value increases by 0.42%.
Lot size-log	Sig (0.1705)	For every 1 % increase in lot size, home value increases by 0.17%.
Age	Sig (-0.0132)	For every 1-unit increase in age, home value decreases by 1.3%.
Basement	Sig (0.0509)	Homes with a basement sell for a 5.1% premium compared to homes w/o a basement.
Facing 51%+ brick	Sig (0.0268)	Homes with more than 50% brick facing sell for a 2.7% premium compared to homes with less than 50% brick facing.
Built-in oven	Sig (0.0414)	Homes with a built-in-oven sell for a 4.1% premium compared to homes w/o a built-in-oven.

# of fireplaces	Sig (0.0259)	For every 1-unit increase in the # of fireplaces, home value increases by 2.6%.
Pool	Sig (0.1068)	Homes with a pool sell for an 11% premium compared to homes w/o a pool.
Detached garage	Sig (0.0510)	Homes with a detached garage sell for a 5.1% premium compared to homes w/o a detached garage.
Attached garage	Sig (0.0770)	Homes with an attached garage sell for a 7.7% premium compared to homes w/o an attached garage.
Source/ Location	Specification	
Haurin and Brasington (1996)	Log-Semi	
Variables	Sig/ Beta	Magnitude of Effect
Age in decades	Sig (-0.0396)	For every 1-unit increase in age, home value decreases by 4%.
Air conditioning	Sig (0.0681)	Homes with a AC sell for a 6.8% premium compared to homes w/o AC.
Deck	Sig (0.0552)	Homes with a deck sell for a 5.5% premium compared to homes w/o deck.
# of enclosed porches	Sig (0.0129)	For every 1-unit increase in the # of enclosed porches, home value increases by 1.3%.
Fireplace	Sig (0.0814)	Homes with a fireplace sell for a 8.1% premium compared to homes w/o a fireplace.
# of full bathrooms	Sig (0.0631)	For every 1-unit increase in the # of full bathrooms, home value increases by 6.3%.
House size (1000 of sq')	Sig (0.4322)	For every 1000 sq' increase in house size home value increases by 43%.
Lot size	NS	No significant effect
# of outbuildings on property	NS	No significant effect
# of partial bathrooms	Sig (0.0567)	For every 1-unit increase in the # of partial bathrooms, home value increases by 5.7%.
Patio	Sig (0.0236)	Homes with a patio sell for a 2.4% premium compared to homes w/o a patio.
Pool dummy	Sig (0.0332)	Homes with a pool sell for a 3.3% premium compared to homes w/o a pool.
# of unenclosed porches	Sig (0.0162)	For every 1-unit increase in the # of unenclosed porches, home value increases by 1.6%.
		Table continues on next page
Source/ Location	Specification	
DeLisle , Huang & Liang (2006)	Log-Semi	
Variables	Sig/ Beta	Magnitude of Effect
# of Bedrooms	Sig (-0.024)	For every 1-unit increase in the # of bedrooms, home value decreases by 2.4%.
# of Bathrooms	Sig (0.017)	For every 1-unit increase in the # of bathrooms, home

		value increases by 1.7%.
Lot size (log)	Sig (0.089)	For every 1 % increase in lot size, home value increases by 0.089%.
Home size (log)	Sig (0.433)	For every 1 % increase in home size, home value increases by 0.43%.
# of fireplaces	NS	No significant effect
Attached garage	NS	No significant effect
Age (years)	Sig (-0.005)	For every 1-unit increase in age, home value decreases by 0.5%.
View (dummy)	Sig (0.160)	Homes with a view sell for a 16% premium compared to homes w/o a view.
Source/ Location	Specification	
Lynch & Rasmussen (2001)	Log-Semi	
Variables	Sig/ Beta	Magnitude of Effect
# of bedrooms	Sig (-0.018440)	For every 1-unit increase in the # of bedrooms, home value decreases by 1.8%.
# of bathrooms	Sig (0.015252)	For every 1-unit increase in the # of bathrooms, home value increases by 1.5%.
Sq. footage	Sig (0.000491)	For every 1-unit increase in sq' footage, home value increases by 0.05%.
Lot size	Sig (0.052427)	For every 1-unit increase in lot size, home value increases by 5.2%.
Central heating unit dummy	Sig (0.100743)	Homes with central heating sell for a 10% premium compared to homes w/o central heating.
Central air conditioning dummy	Sig (0.155000)	Homes with central AC sell for a 15.5% premium compared to homes w/o central AC.
In-ground pool dummy	Sig (0.057248)	Homes with an in-ground pool sell for a 5.7% premium compared to homes w/o an in-ground pool.
Waterfront property dummy	Sig (0.167314)	Waterfront Homes with sell for a 16.7% premium compared to homes not located near water.
Assumable mortgage dummy	NS	No significant effect
Gated community dummy	Sig (0.080666)	Homes in a gated community sell for an 8.1% premium compared to homes not in a gated community.
# of covered parking	Sig (0.107374)	For every additional covered parking space home value increases by 11%.
Dummy for fenced property	Sig (0.046094)	Fenced properties sell for a 4.6% premium compared to properties that are not fenced.
# of fireplaces	Sig (0.048895)	For every additional fireplace home value increases by 4.9%.

Table 3A: Neighborhood Variables Literature Review Table

Source/ Location	Specification	
Song & Knapp (2003)	Log-Lin	
Variables	Sig/ Beta	Magnitude of Effect
SAT score	Sig (0.00192)	For every 1-unit increase in SAT scores, home value increases by 0.19%.
Student/ teacher ratio	Sig (−0.03017)	For every 1-unit increase in the ratio of students to teachers, home value decreases by 3%.
Tax rate	Sig (−0.00408)	For every 1-unit increase in the tax rate, home value decreases 0.004%.
% white	NS	No significant effect
Median household income	NS	No significant effect
		Table continues on next page
Source/ Location	Specification	
Troy and Grove (2008)	Log-semi	
Variables	Sig/ Beta	Magnitude of Effect
Median household income-log	Sig (0.269202)	For every 1 % increase in Median household income home value increases by 0.27%.
% High school graduates	Sig (0.199222)	For every 1-unit increase in % High School, graduates home value increases by 0.2%.
% Owner occupied	Sig (−0.161452)	For every 1-unit increase in % Owner Occupied, home value decreases by 0.16%.
Median age of pop. in BG	Sig (0.009656)	For every 1-unit increase in median age of pop., home value increases by 1%.
Source/ Location	Specification	
Li & Brown (1980)	Linear	
Variables	Sig/ Beta	Magnitude of Effect
Median family income	NS	No significant effect
School dropout	NS	No significant effect
Property tax rates	Not Reported	not reported
School quality	NS	No significant effect
Source/ Location	Specification	
Clark & Herrin (2000)	Log-lin	
Variables	Sig/ Beta	Magnitude of Effect
Median household income	NS	No significant effect
Murder rate	Sig (-0.073)	For every 1-unit increase in murder rate, home value decreases by 7.3%.
% Asian	Sig (-0.0042)	For every 1-unit increase in the % of Asians, home value decreases by 0.0042%.
% Black	Sig (-0.0077)	For every 1-unit increase in the % of Blacks, home value decreases by 0.0077%.

% Hispanic	Sig (-0.0057)	For every 1-unit increase in the % of Hispanics, home value decreases by 0.0057%.
Teacher-student ratio per 100 students	Sig (0.16)	For every 1-unit increase in the Teacher-student ratio, home value increases by 16%.
Dropout rate	Sig (-0.0036)	For every 1-unit increase in the dropout rate, home value decreases by 0.36%.
SAT	Sig (0.0034)	For every 1-unit increase in the % of seniors that took the SAT exam home value increases by 0.34%.
Source/ Location	Specification	
Bowes and Ihlanfeldt (2001)	Log-lin	
Variables	Sig/ Beta	Magnitude of Effect
% Black	Sig (-1.099)	For every 1-unit increase in the % of Blacks, home value decreases by 1.1%.
Median Income	Sig (0.009)	For every 1-unit increase in median income, home value increases by 0.9%.
Crime Density	Sig (-0.056)	For every 1-unit increase in crimes per acre, home value decreases by 5.6%.
Source/ Location	Specification	
Hess and Almeida (2006)	Linear	
Violent Crime	Sig (-291.67)	For every 1-unit increase in the number of violent crimes per capita, home value decreases by $300.
Median Income	Sig (0.36)	For every 1-unit increase in median income, home value increases by $0.36.
Source/ Location	Specification	
Kestens…&Rosiers (2006)	Log-Semi	
Variables	Sig/ Beta	Magnitude of Effect
Income	Sig (0.0166)	For every $10,000 increase in income, home values increase by 1.7%.
% of university degree holders	Sig (0.0050)	For every 1-unit increase in the % of university degree holders, home value increases by 0.005%.
% of unemployed	Sig (0.0013)	For every 1-unit increase in the % of unemployed, home value increases by 0.0013%.
property tax rates	Sig (- 0.1333)	For every 1-unit increase in property tax rates, home value decreases by 0.13%.
Source/ Location	Specification	
Haurin and Brasington (1996)	Log-Semi	
Variables	Sig/ Beta	Magnitude of Effect
Crime Rate (per 1000 residents)	Sig (-2.9273)	For each additional crime per 1000 residents, home value decreases by 300%.

% of Non-white households	Sig (-0.04919)	For every 1-unit increase in the % of non-white HH, home value decreases by 4.9%.
property tax rates	NS	No significant effect
Real income (in thousands)	Sig (0.0021)	For every $1000 increase in income, home values increase by 0.21%.
Test score	Sig (0.0068)	For every 1% increase in the percentage of ninth-grade students who passed all sections of the 1990 Ohio state proficiency test, home value increases by 0.0068%.
Source/ Location	Specification	
Flippen (2004)	Log-Semi	
Variables	Sig/ Beta	Magnitude of Effect
Household income	Sig/ Pos	not reported
Education	Sig/ Neg	not reported
Initial racial composition	Sig/ Neg	not reported
Initial Hispanic origin composition	Sig/ Pos	not reported
Initial poverty composition	Sig/ Neg	not reported
Change in percent Black	Sig/ Neg	not reported
Change in percent Hispanic	Sig/ Pos	not reported
Change in percent poor	Sig/ Neg	not reported
		Table continued on next page
Source/ Location	Specification	
DeLisle , Huang & Liang (2006)	Log-Semi	
Variables	Sig/ Beta	Magnitude of Effect
Elementary public school quality	Sig (0.088)	For every 1 % increase in the passage rate on the WASL Mathematics test at the 4th grade level, home value increases by 0.88%.
Middle public school quality	NS	No significant effect
Median income	NS	No significant effect
% white	Sig (0.250)	For every 1 % increase in % white population, home value increases by 0.25%.
Educational attainment	Sig (0.13)	For every 1 % increase in % of bachelor's degrees or higher, home value increases by 0.13%.
Property tax rates	Sig (-0.090)	For every 1-unit increase in property tax rates, home value decreases by 0.09%.
Source/ Location	Specification	
Lynch & Rasmussen (2001)	Log-Semi	

Variables	Sig/ Beta	Magnitude of Effect
% white	Sig (0.237097)	For every 1 % increase in % white population, home value increases by 0.24%.
% Owner occupied	Sig (0.298836)	For every 1 % increase in % owner occupied homes, home value increases by 0.30%.
% Hispanic	Sig (3.344598)	For every 1 % increase in % Hispanic population, home value increases by 3.34%.
Median household income	NS	No significant effect
% bachelor's degree	Sig (-0.681701)	For every 1 % increase in % of population with a bachelor's degree, home value decreases by 0.68%.
Violent Crime-log	Sig (-0.048419)	For every 1 % increase in the number of violent crimes, home value decreases by 0.048%.
		Table continued on next page
Source/ Location	Specification	
Downes and Zabel (1997)	Log-Semi	
Variables	Sig/ Beta	Magnitude of Effect
Median income of CT-log	Sig (0.2722)	For every 1 % increase in median income, home value increases by 0.27%.
Median age of population in CT	NS	No significant effect
% non-white	Sig (-0.2055)	For every 1 % increase % of non-white population, home value decreases by 0.21%.
Educational attainment	NS	No significant effect
School Quality: average school/district eighth-grade reading component of the IGAP tests-logged	Sig (0.7023)	For every 1 % increase in school quality, home value increases by 0.7%.
property tax rates	Sig (0.6623)	For every 1 % increase property tax rate, home value increases by 0.7%.

Appendix B

The information that follows presents the basic components of linear regression and demonstrates an example of ordinary least squares (OLS). First, begin with the basic equation or linear model, presented below. A linear model is simply an equation created to explain the relationship between the dependent variable (Y) and the independent variable (X). For simplification, in the equation below, only one independent variable is used.

$Y = \beta_0 + \beta_1 X$

Where: Y = Dependent variable

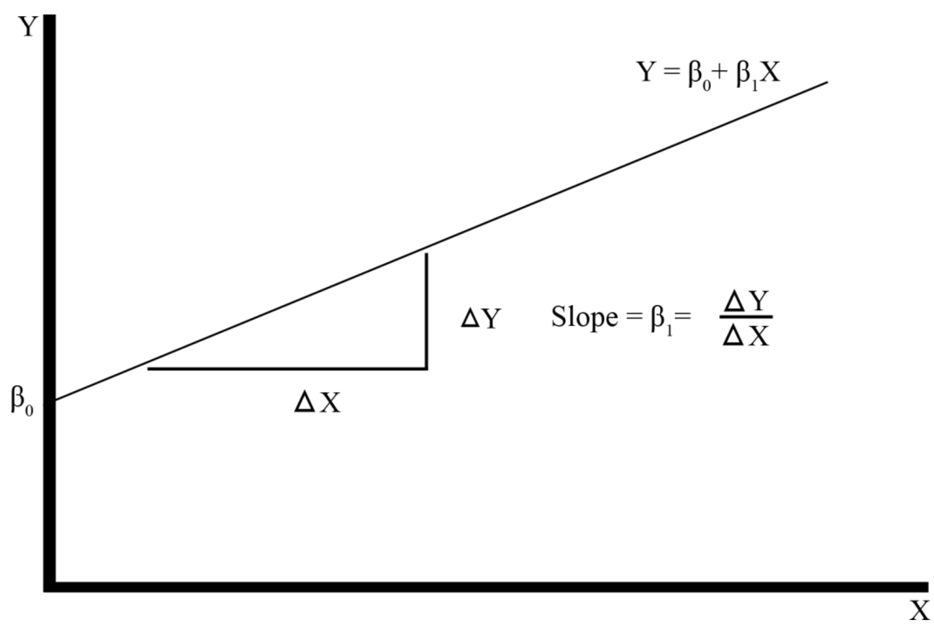
X = Independent variable

β_0 = Constant or y-intercept

β_1 = Slope or Beta coefficient

Figure 1B demonstrates the relationship between Y and X and explains the meaning of β_0 and β_1.

Figure 1B: Slope & Beta coefficients



The positive sloping line represents the linear model or the equation. Beta “knot” (β_0) is where the line (positive sloping line) crosses or intercepts the Y-axis, and where X equals zero. Beta “one” (β_1) is the slope of the line or the change in Y divided by the change in X. “The slope coefficient or β_1 shows the response of Y to a one-unit increase in X” (Studenmund, 2006, p. 8). Interpretation of the Beta coefficients (β_0 and β_1) estimated using linear regression analysis is one of the key elements in understanding the strength of the relationship between and Y and X.

Correctly interpreting the beta coefficients and deducing the relationship between the dependent and independent variables is crucial to regression analysis. Variation is another important concept to understand. Variation is the spread or distribution of the data. It describes the spread in the dependent variable (Y) that is caused by the independent variable (X). Variation is best-shown visually using scatter plots. Figure 2B and figure 3B are two examples of what sample data might look like.

Figure 2B: Scatter plot no variation

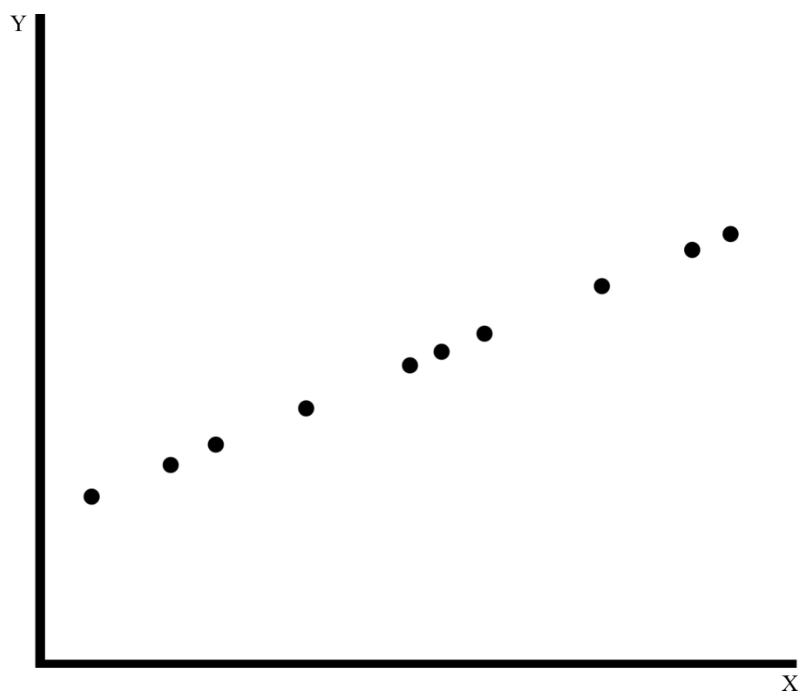
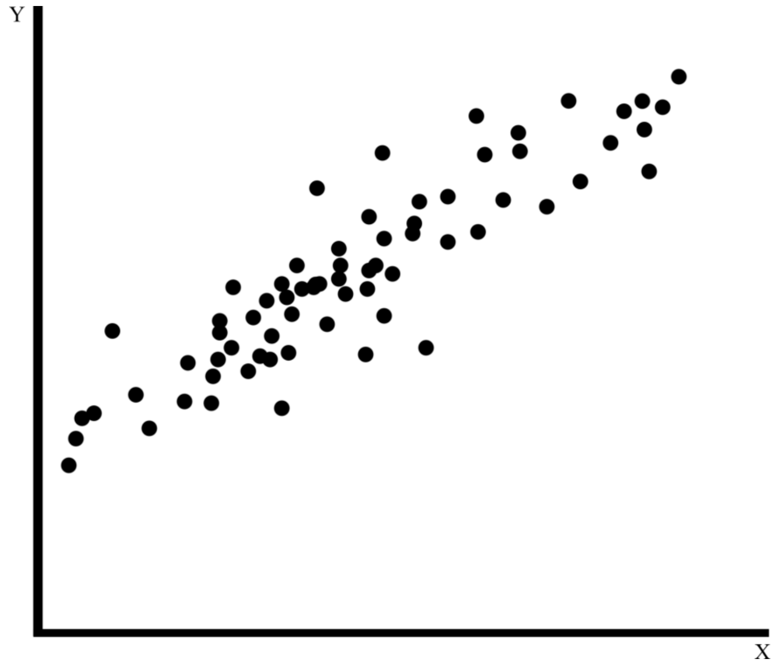


Figure 3B: Scatter plot with variation



It is obvious from figures 2B and 3B the difference in the spread of the data or points. The points in figure 2B appear to fit a straight line and therefore have little or no variation. The points in figure 3B, however, are spread out or scattered and do not fit a straight line perfectly. The spread between the data points in figure 3B is the variation between X and Y. Understanding the variation in data is important in regression analysis because variation affects the "fit" of the line (model). Variation is inherent in all sample data and must be accounted for when using regression analysis. To account for the variation, an error term called the stochastic error term (u) is added to the end of the model. The error term accounts for the "variation in Y that cannot be explained by X" (Studenmund, 2006, p. 10). A complete theoretical linear model is presented below.

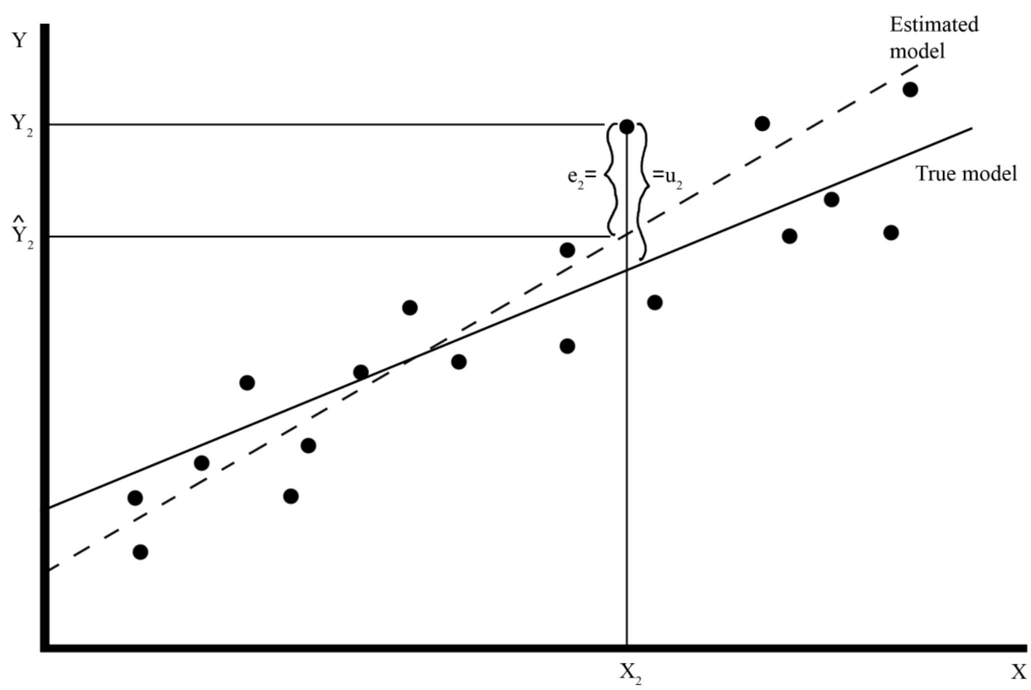
Complete theoretical model: $Y = \beta_0 + \beta_1 X + u$

Where: u = the stochastic error term

Next is to examine the difference between a true model and a hypothetical or estimated model. A theoretical model is a model that is derived from the true population and shows the true relationship between X and Y. In the majority of cases, it is impossible to graph a true model because a complete set of data is impossible to gather. Typically, a smaller subset of data is gathered and analyzed in order to estimate a hypothetical model. Based on a smaller subset of data, the estimated model is used to draw conclusions about the true population.

Figure 4B demonstrates the differences between a true model and an estimated or hypothetical model. The dashed line represents the estimated model. The solid line represents the true or theoretical model. The slope of both lines (models) is different. A number of factors (variation, size of data set, etc.) cause the difference in the slopes of the two lines. The difference in slope is the error in the estimated model.

Figure 4B True model vs. Estimated model



There is an infinite amount of hypothetical models that can be estimated for any set of data. Each hypothetical model will produce a different set of estimates. For instance, in figure 4B the value of X_2 produces two different results depending on the model. The true value of Y_2 is where X_2 crosses the true line (model). However, the hypothetical model estimates Y_2-hat where X_2 crosses the estimated line. The hypothetical model has overestimated the true value of Y_2. The error term u_2 shows the difference between the true value of Y_2 and the sample observation value. The term e_2 is the residual or difference between the estimated value Y_2-hat and the sample observation value of Y_2.

The above discussion introduced the individual components of a linear model. Next I will demonstrate how a linear model is derived mathematically using OLS. Ordinary Least Squares (OLS) is a statistical technique used to estimate the beta coefficients in the hypothetical regression model. OLS attempts to minimize the summation of the squared residuals or minimize the difference between the actual value of Y_2 and the estimated value of Y_2-hat (Studenmund, 2006). OLS tries to "fit" a line (model) as closely as possible between each sample observation, as shown in figure 4B.

The following example demonstrates how OLS calculates the estimated betas from a set of data. First, a set of sample observations is gathered (Table 1B). In this case, the dependent variable Y_z is home sale price and the independent variable X_z is the size of the home in square feet. Six separate calculations based on the sample observations are required to calculate the beta coefficients (row 1 of table 1B). The estimated β's are calculated by using equation 1B and equation 2B.

Table 1B

Sample Observations			Required calculations to estimate Beta coefficients			
n	Y_z	X_z	$(Y_z-\bar{Y})$	$(X_z-\bar{X})$	$(X_z-\bar{X})^2$	$(X_z-\bar{X})(Y_z-\bar{Y})$
1	370000	1364	-6750	79	6196	-531321
2	287500	925	-89250	-360	129806	32155500
3	366000	1347	-10750	62	3809	-663429
4	365000	1182	-11750	-103	10668	1213607
5	410000	1356	33250	71	5001	2351250
6	350000	1053	-26750	-232	53957	6213643
7	365000	1032	-11750	-253	64154	2976107
8	455000	1365	78250	80	6354	6237643
9	425000	1445	48250	160	25509	7706214
10	399000	1120	22250	-165	27319	-3677607
11	371000	1273	-5750	-12	151	70643
12	341000	1750	-35750	465	215959	-16613536
13	400000	1457	23250	172	29486	3992357
14	370000	1325	-6750	40	1577	-268071
Sum	5274500	17994	0	0	579945	41163000
Mean	376750	1285.29				

Equation 1B

$$\hat{\beta}_1 = \frac{\sum_{z=1}^{N} [(X_z-\bar{X}) * (Y_z-\bar{Y})]}{\sum_{z=1}^{N} (X_z-\bar{X})^2}$$

Equation 2B

$$\hat{\beta}_0 = \bar{Y} - \hat{\beta}_1 \bar{X}$$

Plug in the calculations from table 1B into the equations above to obtain the values for each beta coefficient.

$$\hat{\beta}_1 = \frac{41{,}163{,}000}{579{,}944.86} = 70.98$$

$$\hat{\beta}_0 = 376{,}750 - (70.98 * 1285.29) = 285{,}524$$

With both β's calculated, the hypothetical model is stated as follows.

$$\hat{Y}_z = 285{,}524 + 70.98X_z$$

The final step in this simple example of regression analysis is interpreting the estimated β's obtained from the hypothetical model. We are interested in the determining the relationship between home sale price Y_z and the size of a home X_z measured in square feet. β_0 is the constant term or the Y-intercept; it means when the square footage of a home X_z is zero, that home value is $285,524; no other conclusions can be made regarding the β_0 coefficient, though. The most important beta is the β_1 coefficient. The β_1 estimate (+70.98) or the slope of the model tells us, based on the sample observations, that there is a positive relationship between home value and home size; as home size increases home value increases. More importantly, the β_1 coefficient reveals that, for every one-unit increase in the square footage of a home, home value increases by $70.98, all else being equal.

Appendix C

The following eight tables make up the census tract (neighborhood) selection matrix. Column 1 lists all 88-census tracts. Row 1 displays the urban form variables used in the model to calculate the premium for New Urbanist characteristics. The light grey shaded cells represent the top five average values most characteristic of a New Urbanist-style urban form. For example, census tracts 4, 12, 13, 14, and 19 (table C1) have the highest housing unit densities, and higher densities are characteristic of a New Urbanist style urban form, all else being equal. The dark grey shaded cells represent the top five average values most characteristic of a suburban-style urban form. For example, census tracts 96.06, 96.07, 96.08, 96.09 and 96.1 (table C3) are located furthest from the CBD; greater distance from the CBD indicates that these CT's are more characteristic of a suburban-style urban form, all else being equal.

Table C1

CT	Age	Housing Unit Density	Population Density	Land Use Entropy	Non Residential Land Use Entropy	Distance to Commercial	Distance to Central Business District
1	53.6486	4.2800	6.4900	.5200	.3500	1137.4195	16560.5822
2	67.3803	3.1900	9.3300	.2400	.3000	569.5623	14501.5608
3	63.6818	2.9200	8.6200	.4500	.4900	584.5161	10653.3191
4	84.4333	21.6700	15.5700	.8600	.7500	514.2697	6123.8243
12	1.0000	39.0600	17.8100	.9900	.0000	.0000	3325.1100
13	55.5333	32.1700	16.3900	.7500	.7300	346.7627	5670.0727
14	86.2500	37.7200	13.7800	.8700	.8500	231.1238	5134.1150
15	80.1091	7.1500	10.6100	.4000	.3700	451.6527	9923.7662
16	67.8721	3.2500	6.6600	.4600	.4200	537.6837	14976.5271
17	69.4521	4.5200	5.5600	.6200	.5600	877.8016	16312.9722
18	77.3619	9.2900	12.5200	.4200	.3500	376.3988	11914.9058
19	90.7619	21.2600	10.6000	.7400	.7600	490.0019	6217.9576
20	68.1818	19.5700	10.5000	.7600	.7100	200.3645	4345.1909
21	48.2308	11.2200	6.7300	.8800	1.0000	339.2315	4672.7623
22	66.7083	5.1400	6.3000	.6900	.5400	990.5948	8840.2325
23	76.6234	8.6400	10.5900	.4900	.0000	723.9190	6849.1334
24	69.8254	3.2600	5.5300	.2000	.1900	929.7244	10612.5683
25	77.9500	6.5800	6.8800	.8900	.9200	591.4895	11931.2435
26	83.5814	8.6000	11.7300	.4900	.0000	500.7435	8995.5844
27	71.1545	8.0000	12.3400	.4300	.4800	412.5120	13043.4053
28	66.3774	7.0600	15.3800	.4200	.0000	501.3017	15410.2086
29	65.5068	6.1600	8.3600	.6200	.6800	728.1116	19273.2988
30	54.9365	5.1800	10.9500	.6300	.6200	1690.6179	23050.1515
31.01	56.2977	4.9100	11.8200	.7000	.6200	1211.0105	27512.4236
31.02	57.0854	6.8000	11.7700	.6600	.0000	947.4313	23546.5071
32.01	30.7814	4.1300	13.1500	.2200	.0000	1224.6623	29615.8468
32.02	58.0690	5.8200	11.6600	.5500	.0000	716.7026	25910.6195
33	56.3043	3.2000	6.9700	.3100	.0000	963.5243	17462.2685
34	48.5294	3.2900	7.3500	.3600	.4300	1141.1228	22662.8566
35.01	61.3000	6.9100	9.5800	.6300	.7100	400.7933	15659.0800

Table C2

CT	Age	Housing Unit Density	Population Density	Land Use Entropy	Non Residential Land Use Entropy	Distance to Commercial	Distance to Central Business District
35.02	58.7544	1.4300	10.3300	.2000	.2500	639.4012	18803.9604
36	59.5636	5.0900	9.7400	.6900	.7600	620.3336	16198.9458
37	54.0602	6.2800	13.1700	.3900	.4200	561.0552	16186.7724
38	51.0154	1.6500	4.3600	.1300	.0000	2035.7914	26688.7981
39	52.2051	4.1000	6.1800	.5400	.3500	1111.3077	18717.7913
40.01	40.3214	3.7700	7.5300	.3100	.3700	1317.2318	27233.9707
40.04	31.2708	4.4500	8.8300	.6500	.5500	2621.9992	31051.3379
40.05	36.4583	4.5600	8.0200	.6600	.5100	1975.8671	27296.2079
40.06	41.1579	5.8600	10.8100	.9900	.0000	2653.9258	27195.9589
40.08	25.4500	3.5800	9.6200	1.0000	.0000	3082.6835	34663.5605
40.09	25.2368	5.6100	11.7400	.2700	.3300	1246.4671	34166.4645
40.1	19.6429	8.2300	11.3400	.5500	.5900	963.7729	34276.3893
40.11	10.9524	4.4500	9.1600	.3900	.4500	1428.5038	36671.2843
40.12	18.9524	5.1300	6.6600	.5900	.4100	1780.0771	37075.5605
41	37.3293	4.0500	10.3200	.4900	.4400	1252.1720	25495.8920
42.01	48.4310	5.0200	12.2100	.3900	.0000	1529.4068	32001.5889
42.02	41.6591	5.5400	14.4000	.2600	.3100	1701.2481	32182.2405
42.03	44.2105	3.4200	12.0300	.4400	.0000	1195.1132	32689.1239
43	25.8333	1.5100	7.0500	.3800	.3400	1546.5100	36341.7351
44.01	49.6944	15.9300	12.9400	.9000	.0000	459.5753	21096.7633
44.02	53.4167	14.9100	14.4300	.3900	.0000	558.7342	17286.4075
45	59.3043	11.5200	7.3000	.7900	.8600	626.3943	20721.4974
48.01	31.2577	5.0100	12.0200	.3400	.0000	1409.6070	32636.6762
49.03	26.2000	6.4300	15.6900	.5600	.6400	1177.8062	33597.6683
49.05	39.0816	8.8300	16.3600	.7500	.0000	926.8297	38223.1146
49.06	16.8815	3.8100	9.7500	.6300	.6800	933.5185	36791.4692
52.02	36.6512	2.1400	6.8200	.9600	.0000	3084.4309	29339.4128
52.03	44.0400	8.3600	2.3000	.7200	.6400	1310.6098	30094.7314
54.03	35.6667	8.3900	6.7200	.4800	.4000	553.2833	22982.9767
54.04	36.2000	19.1900	5.3600	.9100	.9200	951.1040	25602.0800

Table C3

CT	Age	Housing Unit Density	Population Density	Land Use Entropy	Non Residential Land Use Entropy	Distance to Commercial	Distance to Central Business District
55.02	56.3906	15.7000	7.8500	1.0000	1.0000	676.3839	22095.5867
62.02	61.2766	10.8200	9.6800	.6600	.5000	465.9289	24772.9326
63	52.8814	4.4600	6.4700	.6000	.4900	539.9687	24008.9287
64	48.7316	4.1900	6.3000	.7600	.8000	778.6549	30335.8241
70.09	8.2048	1.9500	1.8100	.7800	.7800	1813.2153	17306.2733
70.1	10.8889	6.5800	4.1200	1.0000	1.0000	402.9600	16096.8189
70.11	25.7465	8.6200	12.7500	.5700	.5800	1382.8065	17326.6507
70.12	27.7097	6.5300	12.7000	.4300	.5000	1331.9021	16203.1750
70.13	30.2273	4.6600	17.4100	.0500	.0000	1651.6858	17738.1250
70.14	30.5263	6.5400	14.8100	.2000	.2500	1729.2947	14694.6279
71	6.8235	.2000	.0400	.6700	.5700	1373.0580	35964.1949
72.04	21.6826	1.6800	2.1200	.8000	.6800	1933.0598	32084.4302
96.01	27.0281	1.4300	3.8000	.7100	.7800	2276.1023	40272.6264
96.06	32.5642	7.1800	10.8500	.8800	.9400	1156.3331	44540.6235
96.07	28.8239	7.6900	17.9800	.4700	.5500	2403.4875	42653.0023
96.08	17.9873	1.8400	2.9000	.8700	.9300	729.8257	52199.0963
96.09	18.2802	6.0200	12.8100	.5900	.5900	1486.0174	49890.9720
96.1	24.3000	5.0500	13.5500	.5200	.0000	2856.8724	46500.4839
Total	35.4113	4.3895	8.2937	.5720	.4684	1263.9100	27939.4088

Table C4

CT	Distance to Light Rail Station	Distance to freeway onramp	Home within 1,400 feet of commercial service	Home within 1,400 feet of a light rail stop	Home within 1,400 feet of a park	Number of Blocks	Block Perimeter	Mean street length
1	7935.9159	3816.3530	.6486	.0000	.8649	.0766	4.0130	.9269
2	6064.3799	3705.2483	1.0000	.0000	.4366	.2239	4.5044	.9915
3	6387.6266	2632.8636	1.0000	.0000	.8182	.1633	5.2284	1.1639
4	4818.7703	1718.7840	1.0000	.0000	.8667	.4081	3.9883	1.1857
12	2261.0200	3449.7800	1.0000	.0000	.0000	.4542	6.4683	1.5649
13	1532.6727	1244.7747	1.0000	.4667	.9333	.4423	5.2058	1.4486
14	3732.8138	1946.1413	1.0000	.0000	.8750	.4356	5.2015	1.4504
15	2133.7285	1475.2276	.9818	.2545	.5273	.2066	4.0005	.7820
16	2591.8102	1962.1984	.9767	.1744	.6395	.1323	2.7367	.5254
17	1772.8440	1014.7856	.8630	.3288	.5205	.1330	2.0312	.4128
18	3438.9752	2474.6973	1.0000	.0286	.9238	.2872	3.1557	.6983
19	1477.1233	773.8729	1.0000	.4286	.1429	.3988	3.4406	.9377
20	1746.6200	490.2200	1.0000	.0909	.0000	.3832	4.1642	1.0311
21	2927.6392	433.6000	1.0000	.0000	.9231	.2475	2.7141	.7138
22	5664.5885	2174.7598	.8125	.0000	.9583	.0595	3.2163	.7139
23	1782.6827	1927.1714	.8312	.3636	.1948	.2264	5.5127	1.1778
24	2988.9429	3232.4703	.7619	.2381	1.0000	.0864	3.1843	.5021
25	2036.2855	1625.6120	1.0000	.1500	1.0000	.1865	8.3504	1.4498
26	2342.7393	1588.6505	1.0000	.2558	.8372	.2587	6.8062	1.4134
27	4675.6079	1208.7510	1.0000	.0000	.9818	.3053	4.3138	.9059
28	6061.8702	4179.0054	1.0000	.0000	.7044	.2586	7.0188	1.3565
29	4562.9259	3654.4621	.9315	.0000	.5890	.1362	3.9971	.6539
30	6154.7408	5441.0211	.3810	.0000	.4841	.1344	3.5077	.6085
31.01	7391.8731	7847.1394	.5802	.0000	.9160	.1159	7.5846	1.4950
31.02	9164.9004	7346.4757	.7927	.0000	.3659	.1394	8.1359	1.4701
32.01	11075.1310	9745.0960	.5674	.0000	.7256	.0879	4.8286	.6594
32.02	11168.8926	7515.9944	.8621	.0000	.1494	.1098	5.7887	1.0389
33	6408.7013	3724.3211	.7609	.0000	.6957	.1098	6.7330	.7295
34	8647.1581	3819.6787	.6765	.0000	.9559	.0934	4.9189	.9419
35.01	2898.5260	4073.3850	1.0000	.0000	.4667	.2223	6.7435	1.2073

Table C5

CT	Distance to Light Rail Station	Distance to freeway onramp	Home within 1,400 feet of commercial service	Home within 1,400 feet of a light rail stop	Home within 1,400 feet of a park	Number of Blocks	Block Perimeter	Mean street length
35.02	2121.1565	4648.0209	.9474	.3860	.9123	.1620	6.3667	1.3522
36	2432.8718	1749.8109	1.0000	.0909	.8364	.0989	7.4656	1.4974
37	4675.2130	1296.2094	1.0000	.0000	.6084	.2549	4.3972	.9425
38	4483.2535	6775.8141	.3000	.0000	.5385	.0468	1.8785	.4137
39	10518.8349	1114.3577	.7179	.0000	1.0000	.0949	3.9405	.7045
40.01	11381.8571	1378.7716	.6250	.0000	.9286	.0899	2.9374	.5561
40.04	20756.5371	7877.7756	.2083	.0000	.7500	.0890	3.4112	.4993
40.05	16627.1913	4230.3792	.2500	.0000	.7083	.0610	4.7875	.7829
40.06	13744.3600	1558.3579	.1579	.0000	.8947	.0751	5.6610	.9443
40.08	21131.7005	7226.5200	.0500	.0000	.8000	.0931	5.9749	.9542
40.09	18392.7613	4839.4303	.6579	.0000	1.0000	.0648	5.2762	.8102
40.1	15588.3582	2821.1964	.8214	.0000	.6429	.0559	8.7735	.9369
40.11	17159.5967	4032.9576	.4762	.0000	.6667	.0364	9.7601	1.1318
40.12	15646.5281	3120.8914	.4762	.0000	1.0000	.0482	4.1159	.7420
41	1980.0022	4962.9506	.5976	.1951	.6829	.1984	3.2678	.8544
42.01	8401.4233	3604.7270	.4253	.0000	.9885	.1153	5.4978	1.0880
42.02	5545.7695	6306.2709	.4034	.0000	.9318	.1110	6.5060	1.1466
42.03	2570.5639	7735.9216	.6105	.1158	.9789	.0866	6.5473	1.0577
43	6994.7201	5042.4605	.4329	.0185	.8125	.0662	2.6310	.4792
44.01	8850.4225	4724.8728	1.0000	.0000	1.0000	.0702	6.5322	1.1566
44.02	5750.8431	2228.5083	1.0000	.0000	.3333	.0293	9.9705	1.0279
45	2027.5587	1900.3583	.9130	.1087	.7174	.0553	3.6448	.3785
48.01	14502.1749	7727.4405	.4845	.0000	.7320	.0840	6.3200	.8366
49.03	2102.6797	4880.8981	.5806	.1806	.8839	.0887	5.5577	.8299
49.05	6061.8481	3743.3293	.8231	.0000	.4966	.0797	7.3644	.9712
49.06	3263.3610	6560.9185	.8148	.0296	.2370	.0675	10.4256	1.6743
52.02	4364.6728	1022.1679	.0233	.0000	.9767	.0532	5.5066	.7013
52.03	2742.5268	1219.0876	.5800	.0000	.7600	.0203	.9060	.1694
54.03	6248.1867	3316.4567	1.0000	.0000	.6667	.0230	17.0779	2.4208
54.04	7088.9840	3553.4240	.8000	.0000	1.0000	.0155	4.0591	.4432

Table C6

CT	Distance to Light Rail Station	Distance to freeway onramp	Home within 1,400 feet of commercial service	Home within 1,400 feet of a light rail stop	Home within 1,400 feet of a park	Number of Blocks	Block Perimeter	Mean street length
55.02	4697.9720	1818.1988	.9531	.0000	.5469	.0490	3.4207	.6832
62.02	2055.3255	670.8157	1.0000	.2553	.6170	.0915	5.7505	1.0366
63	2907.4588	2965.9753	.9576	.0254	.6356	.0928	3.1774	.6334
64	5332.9243	1125.2689	.9158	.0000	.3579	.1311	2.3597	.4794
70.09	9560.2345	2040.6372	.4699	.0000	.3494	.0520	3.9341	.5504
70.1	6605.6944	1387.1000	1.0000	.0000	.0000	.0214	5.0514	.4301
70.11	3802.6020	1024.6683	.4930	.0000	.7465	.0491	7.1147	.7780
70.12	1603.5415	2473.3811	.4677	.3065	.8548	.0708	16.5380	1.5091
70.13	2190.0439	3297.6514	.4697	.2273	.5000	.1436	17.8276	2.3799
70.14	2133.4879	4730.7833	.2895	.2895	.9408	.0939	5.7112	.9502
71	5116.4596	5818.0583	.5857	.0319	.0017	.0117	.0868	.0162
72.04	14678.6065	5897.7916	.4192	.0000	.8982	.0217	1.5368	.2689
96.01	2664.5216	8921.3229	.2249	.1446	.8554	.0249	1.4166	.1968
96.06	2601.8834	2389.6891	.6201	.2235	.7039	.0577	3.8669	.7535
96.07	2584.4146	5161.5250	.2465	.0739	.9014	.0962	6.4086	.8638
96.08	2497.2804	4888.0619	1.0000	.0759	.9873	.0549	2.9493	.4822
96.09	4522.8523	6574.0679	.4286	.0000	.8297	.0902	7.7153	1.0238
96.1	2681.8546	6567.1713	.1040	.1920	.6960	.0913	6.5023	.8312
Total	5785.0761	4401.7530	.6354	.0580	.6139	.0920	3.8949	.6533

Table C7

CT	Ratio of street segments to intersections	Square footage
1	.0029	1465.0811
2	.0046	1389.7324
3	.0046	1388.6364
4	.0077	1516.0667
12	.0143	2400.0000
13	.0094	1292.1333
14	.0086	1485.1250
15	.0036	1385.3091
16	.0024	1434.5698
17	.0019	1198.4384
18	.0036	1147.1524
19	.0049	1366.6190
20	.0074	1140.0000
21	.0033	1461.5385
22	.0020	1261.6458
23	.0064	1318.5195
24	.0021	1626.0159
25	.0082	1555.4500
26	.0067	1374.8140
27	.0045	1093.6909
28	.0072	1070.8176
29	.0034	1115.4384
30	.0027	1208.8095
31.01	.0047	1051.0916
31.02	.0051	1253.7073
32.01	.0026	1409.0558
32.02	.0056	1015.8161
33	.0027	1680.6087
34	.0030	1577.8235
35.01	.0053	1231.1000

Table C8

CT	Ratio of street segments to intersections	Square footage
35.02	.0050	1125.0351
36	.0043	1024.5818
37	.0042	1023.1084
38	.0011	1290.1000
39	.0024	1587.1538
40.01	.0017	1804.3929
40.04	.0020	2080.2083
40.05	.0024	2098.0417
40.06	.0030	1834.0000
40.08	.0033	1649.4500
40.09	.0025	1731.5789
40.1	.0032	1802.3929
40.11	.0063	2961.9048
40.12	.0031	2595.8095
41	.0027	1276.5976
42.01	.0034	1249.9598
42.02	.0036	1328.1080
42.03	.0034	1192.3684
43	.0013	1607.8310
44.01	.0059	1114.5833
44.02	.0039	1074.4722
45	.0028	1105.9130
48.01	.0034	1437.0825
49.03	.0041	1546.5484
49.05	.0039	1386.6735
49.06	.0081	1500.6074
52.02	.0041	1648.0233
52.03	.0006	1582.9400
54.03	.0059	1824.3333
54.04	.0016	2228.2000

Table C9

CT	Ratio of street segments to intersections	Square footage
55.02	.0021	1176.5156
62.02	.0043	1038.7234
63	.0023	1092.6441
64	.0021	1059.5263
70.09	.0030	2123.5422
70.1	.0073	1623.2222
70.11	.0056	1520.3380
70.12	.0063	1435.4677
70.13	.0103	1423.4697
70.14	.0035	1440.8026
71	.0001	2179.6210
72.04	.0008	1540.5629
96.01	.0010	1448.2450
96.06	.0024	1380.6983
96.07	.0037	1306.0775
96.08	.0018	1686.1646
96.09	.0044	1635.9341
96.1	.0034	1405.0000
Total	.0027	1490.1307

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