VALUE OF WALKABLE COMMUNITIES

A Thesis

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by

Corina Cisneros

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Abstract

of

VALUE OF WALKABLE COMMUNITIES

by

Corina Cisneros

The intent of this research is to determine what factors create walkable

communities, and for the information learned to be a useful tool to promote community

change with the goal of sustainable community design. One part of creating sustainable

communities is knowledge on the degree of walkability because this community feature

ties into so many other aspects of the health, social, and environmental concerns of a

community. Increased awareness and investment in walkable communities promotes

change that benefits individuals, communities, and society as a whole.

This thesis demonstrates the importance of walkability in sustainable community

design and how it can fit in with long range planning and policy directives supported at

the national, state, and local level. Analysis of the association between home values in the

Sacramento area and the degree of walkability of a home using Walk Score indicated

limitations with the data set. Based on the limitations found during this research I propose

an empirical measure of walkability that can be applied as a planning and development

tool to create walkable communities. The goal is to further explore the link between

residential land values and walkable communities.

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Date

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Chapter 1

THE IMPORTANCE OF WALKABLE COMMUNTIES

As a child growing up in Southern California I experienced traffic, pollution, and overcrowding. I can still vividly remember days when we were not allowed to play outside because the air pollution was so bad it would make us sick. My family lived in the San Fernando Valley and I still recall knowing it was a clear beautiful day when we could see the mountains that surrounded the valley, most of the time there was a thick haze limiting our view. Based on these observations as a child I knew the greater Los Angeles area was not good place to live. As I grew older and began college did I really begin to understand why Los Angeles developed the way it did. I began to reflect about the development policies that government's support and how certain policies can have a lasting and profound effect on the development of cities. One can only imagine how Southern California would have developed if the powers that be had continued to expand the trolleys and other public transportation networks, focused development on walkable communities, and less investment on freeways and private automobile transportation. Perhaps the greater Los Angeles area would be a model of health and vibrancy instead of the sprawl and congestion we know it now to be.

The desire for changing the way cities, communities, and neighborhoods develop from this point forward have been vocalized by policy makers at the federal, state and local level. At the federal level incremental changes in policy and directives have called for the creation and support of more walkable communities. The following quote

summarizes the idea envisioned in this thesis "Walkable communities are urban places that support walking as an important part of people's daily travel through a complementary relationship between transportation, land use and the urban design character of the place. In walkable communities, walking is a desirable and efficient mode of transportation" (Institute of Transportation Engineers, 2012, p. 64).

The federal Department of Transportation (DOT) Bicycle and Pedestrian Program announced a policy statement in Spring 2010 for support and development of an integrated transportation network which included connected walking and biking networks, "Walking and bicycling foster safer, more livable, family-friendly communities; promote physical activity and health; and reduce vehicle emissions and fuel use" (www.dot.gov) In conclusion the policy statement indicated that although DOT can be the leader with its federal directives and support, it is ultimately up to the transportation agencies across the nation to implement the policies. The agency with the greatest impact on national housing development and direction, The U.S. Department of Housing and Urban Development (HUD) has also acknowledged the need to create walkable communities that are healthier for people and the environment. In partnership with DOT and the Environmental Protection Agency (EPA), HUD's Office of Sustainable Housing and Communities has coordinated the offer of Sustainable Communities Planning Grants "…In order to better connect housing to jobs, the office will work to coordinate federal housing and transportation investments with local land use decisions in order to reduce transportation costs for families, improve housing

affordability, save energy, and increase access to housing and employment opportunities (www.hud.gov)". Under federal direction there has been a growing awareness to change policy and planning in regards to urban planning, transportation planning, and environmental stewardship, but as indicated by the DOT, responsibility for action and real change must be implemented by individual states and communities.

This thesis will demonstrate the importance of walkability in sustainable community design and how it can fit in with long range planning and policy directives supported at the national, state, and local level. Ultimately, this thesis will analyze the association between home values in the Sacramento area and the degree of walkability of a home. Ultimately, I will propose an empirical measure of walkability that can be applied as a planning and development tool to create walkable communities. The purpose is to further explore the link between residential land values and walkable communities. If there is in reality a premium for homes in walkable communities, this will help support the policy directives highlighted previously at all levels of government. It will also help housing consumers to make educated decisions on where they choose to vote with their housing dollars, walkable communities or car dependent ones, and will send a message to developers and the public agencies in support of development how best to plan and prioritize funding. The remainder of this chapter will introduce the Walk Score walkability measured examined in this thesis; the housing and demographic market of Sacramento; and concludes with the specific research questions and description of the remaining chapters in this thesis.

Walk Score and Sacramento Real Estate Market

Walk Score was developed in 2007 with the stated mission "to promote walkable neighborhoods. Walkable neighborhoods are one of the simplest and best solutions for the environment, our health, and our economy" (walkscore.com). The website states Walk Scores are shown for over 20 million locations every day and are used on over 30,000 sites. Walk Scores are given for a location with a number of how walkable that location is from 0-100 scale.

Walk Scores

90-100- Walker's Paradise- daily errands do not require a car.

70-89 Very Walkable- most errands can be accomplished on foot.

50-69 Somewhat Walkable- some errands can be accomplished on foot

25-49 Car Dependent- most errands require a car.

0-24- Care Dependent- almost all errands require a car.

(https://www.redfin.com/how-walk-score-works)

The following table information was taken directly from Walk Scores website for Sacramento. Sacramento as a whole Walk Score is 43 which is considered Car Dependent. Individual communities in Sacramento are listed below. As shown those locations closer to the central business district have a higher Walk Score. Both Downtown and Midtown are considered a Walker's Paradise. This is evident from anyone with familiar with these areas due to the shops, restaurants and other amenities within close walking distance.

Table 1. Sacramento Walk Scores

Location	Walk Score	Population
Downtown	91	6,512
Midtown	90	8,586
Old North Sacramento	76	4,508
North Oak Park	75	4,388
Hollywood Park	70	2,376

(**https://www.walkscore.com/CA/Sacramento**)

Sacramento Real Estate Market

The Sacramento region, much like the rest of the state and nation was not immune from the economic recession that greatly devastated the local housing market beginning in 2006 -2007. Although, traditionally California home values are greater than the nation due to a variety of factors, the Sacramento area witnessed a far greater share in declining home values and foreclosures. From 2007 to 2010 foreclosure activity increased over 64 percent in the region and some communities in Sacramento witnessed a decline of over 62 percent in home values. (SACOG, 2011). The situation has improved with new data showing a decrease in foreclosures and a steady return of the housing to a normal pace of growth. Zillow recently listed Sacramento as the eighth best market to sell a single family home in the United States (Sacramento Business Journal, 2015).

As the real estate market becomes less volatile and consistency and growth return to normal it is imperative that planners, policy makers, and government officials recognize the need to accommodate developments that are more reflective of changing preferences and demographics. A variety of research has identified factors such as an aging and significant baby boomer population that does not prefer large lot single family housing and the current younger generation that desires housing close to work, shopping, and dining. The Director of the Metropolitan Research Center at the University of Utah Arthur Nelson's research suggests that over half of the developments in 2025 will not have existed in 2000 due to changing land use patterns and the preference of the two groups identified previously. He identifies the need for housing units such as apartments, town homes, and condos and small lot-houses in the future (SACOG, 2010). Jonathan Rose the CEO of a national development and investment firm states, "It is very unlikely that new projects in sprawl areas will be financed. Urban areas with diverse transit options and thriving universities are the choice for Baby Boomers and young people (Leinberger, 2010)".

In addition to the policy and demographic changes, actual consumers are demanding a shift from current housing types. A preference is indicated all over the country for sustainable, smart growth, and walkable communities. In the winter 2010 National Association of REALTORS (NAR) publication "On Common Ground", the focus was on 'green communities'. From Florida to Oregon realtors are noting the public desire for walkable communities. A pendulum shift is occurring in the real estate market

where a premium is placed on homes in walkable communities versus auto-orientated suburbs. One REALTOR summarized this shift as not merely a trend but a new way of life. A Portland, Oregon REALTOR explained from personal experience her clients "Are willing to pay more for a home – or accept less in terms of square footage and amenities – in exchange for proximity to shopping, entertainment, work and school (On Common Ground, 2010)." A 2011 survey by NAR also indicates consumer preference for walkable communities. It was found 56 percent of Americans prefer walkable mixed used neighborhoods over ones that where they have to drive more between work and home (NAR 2011).

The Sacramento region is not exempt from these changing demographics and regional plans, the Sacramento Area Council of Governments (SACOG) a regional planning organization in the area developed the in process Metropolitan Transportation Plan/Sustainable Communities Strategy 2035, which identifies the need for future growth to shift towards developments closer to work and services, smaller lots and attached units and increased rental units to satisfy demand (SACOG, MTP/SCS 2035). Growth is predicted to shift from 35 percent single-family small lot and attached units and 65 percent single family large-lot in 2008 to 62 percent and 38 percent respectively by 2020. This represents a complete turnaround in the future development of communities in the region.

Overview of the Remainder of this Thesis

State laws are demanding a new way of planning and development. At the individual level people are demanding the creation of walkable communities. Taken together the writing is clear, a shift towards revitalizing existing communities towards walkability as well as planning for new developments with the same focus is paramount to our success as a nation, state, city and finally community. One area that can address both the health and environmental welfare of our region is to develop tools that promote walking not only as a source of physical activity but encourage it as a sustainable transportation mode for work and leisure. The research agenda for this thesis is the starting point on which to formulate policies and objectives aimed at identifying those places in which to focus incentives for creating walkable, sustainable communities.

Specifically, this thesis will analyze the relationship between homes values and Walk Score in select neighborhoods within the City of Sacramento and to systematically evaluate whether Walk Score as a measure of walkability alone should be applied as a planning tool to combat the negative associations of sprawl and poor planning discussed previously. My prior research on this subject has indicated homes in walkable neighborhoods can command a premium in the housing market, but as with any research more analysis and variables are needed to determine if Walk Score alone should be applied to determine the best measures of walkability. What this thesis will do is evaluate Walk Score, discuss the criticisms found in my prior research as well as new research and

empirically formulate a method of measuring walkability as planning and development tool.

The thesis is organized as follows. In Chapter 2 I will present a Literature Review to acquaint the reader with previous research on this topic as well as provide a basis for comparison to different research models. This chapter will discuss relevant research on walkability as a planning tool, the research utilizing Walk Score, and limitations and criticism of Walk Score research. Chapter 3 details the methodology used in this thesis to generate the Walk Score regression. I used an Ordinary Least Squares (OLS) regression model to determine the relationship between home value and Walk Score. This chapter provides a clear understanding of the explanatory variables chosen and their anticipated influence on home value, and indicates the data and sources used in the thesis which is compiled in a data table format to allow for ease of dissemination and discussion. In Chapter 4 the results of the regression analysis are reviewed and explained. Chapter 4 organizes the results obtained from the analysis and discusses the findings, and proposes an empirical way to measure walkability that does limit walkability measurements strictly to Walk Score data. Chapter 5 concludes with reflections on the regression model, how to interpret the significant results, and suggestions for improving Walk Score or starting fresh with a new empirical measure of walkability that can be applied to promote change for future policy directions and initiatives.

Chapter 2

LITERATURE REVIEW OF WALKABILITY: BENEFITS, HEDONIC PRICE

MODEL, AND WALK SCORE

This chapter will be organized around four main themes: 1) the benefits of

walkable communities, 2) the nature of the hedonic price model and relevant literature on

neighborhood design characteristics that may influence walkability, 3) research on

walkability and Walk Score, and finally 4) limitations of Walk Score. The focus of the

literature review will be to discuss the findings of each theme and how they relate to

walkability. This is done with an eye toward formulating a new methodology for

walkability and its role in home value.

Benefits of Walkability

This chapter begins with a review of the benefits of walkability found in research

literature. I believe intuitively many people know there are benefits of walking and

exercise in general. We know we feel better when we move our bodies, but what

specifically are the benefits of communities that promote walking as a form or transport

and leisure? The answer to this question is important because if one is to develop a

comprehensive model that measure walkability, one must know how that measure is

intended to facilitate acquisition of specific benefits.

Academic research has examined the link between walkability and desirable

community design. Fueling this growing academic research field are concerns about the

health of the nation, environmental degradation, and a desire by many in the planning

profession to address these circumstances with focus and attention on sustainable

communities (Giles-Corti et al, 2015, Giles-Corti et al, 2014, Pivo & Fisher, 2011).

Walkable communities are one part of this dynamic of creating vibrant, healthy, and

livable places. The walkability of a community is an essential component of sustainable

community design and the health, social, and environmental benefits are indicators of

overall community health and vibrancy.

<u>Health Benefits</u>

There is a growing amount of research and data to support the claim that walkable

communities can be an important aspect of a healthy active lifestyle (Lovasi, Grady, and

Rundle, 2012, Duncan et al, 2011, Giles et al, 2009, Saelens & Handy, 2008). Our society

is battling a growing epidemic of health diseases and problems attributed to a sedentary

lifestyle (Pivo & Fisher, 2011). Estimates indicate physical inactivity is responsible for

over five million deaths annually throughout the world (Giles-Corti et al, 2015).

Obesity accounts for many health problems such as cardiovascular disease, cancer and

diabetes. Information obtained from the Centers for Disease Control (CDC) on health

risks such as obesity facing Californians, and specifically people living in the U.S.

Census defined Sacramento Metropolitan Statistical Area, indicate alarming rates of the

population battling these health problems (www.cdc.gov). However, the link between

the built environment and the degree of physical activity that communities engage in

increasingly shows a relationship (Giles-Corti et al, 2015, Frank et al, 2004, Goldberg,

2007, Saelens & Handy 2008). Built environments and communities that encourage

walking and biking can have a positive impact by addressing physical inactivity and sedentary lifestyles according to information obtained from the Alliance for Biking and Walking 2012 Benchmarking Report (Bicycling and Walking in the United States 2012 Benchmarking Report). The report provides reliable and relevant data to government and elected officials to base support and sound decision-making for policies to increase walking and biking as a viable transportation alternative to car use. What makes this report unique and worth discussing is the specific data about Sacramento. Sacramento ranks third in per capita spending of federal money for bicycling and walking between the years 2006-2010 and ranks fifteenth for bicycle and walking levels in the same years (Bicycling and Walking in the United States 2012 Benchmarking Report, 2012).

The nation has seen alarming growth in the number of overweight and obese people, especially among children and young adults. Analyzing data going back to the 1960s, the Alliance for Biking and Walking 2012 report shows that as Americans have decreased their use of walking and biking as a transportation option, the percent of Americans classified as obese soared (2012 Benchmark Report). Based on the 1960 Census and CDC data almost ten percent of trips to work was by walking and the obesity rate for adults was less than fifteen percent. By 2009 the obesity rate for adults nearly reached thirty-five percent of the population, and walking or biking to work was down to less than four percent of trips. For children the data is similar. Beginning with the years 1966-1969 the obesity rate for children was around four percent and the percent of kids who walked or biked to school was almost forty-five percent. By 2009 the obesity rate for

children was close to eighteen percent and the percent of kids who walked or biked to school had fallen to around ten percent (Benchmark 2012).

      The following U.S. Obesity Trends maps from the CDC illustrate the rising levels of obesity rates throughout the nation. The first map shows California in light blue with an obesity rate of less than 10 percent in 1990, the second map with California a dark blue shows an increase in the obesity rate ranging between fifteen and nineteen percent of the population by 2000, the last map indicates California had reached obesity rates ranging between twenty to twenty-four percent of the population in 2010 (Obesity Trends 2010, CDC).

Figure 1. United Sates Obesity Trend 1990, 2000, 2010

Obesity Trend 1990	Obesity Trend 2000	Obesity Trend 2010

	No Data		<10%		10%-14%		15%-19%		20%-24%		25%-29%		<30%
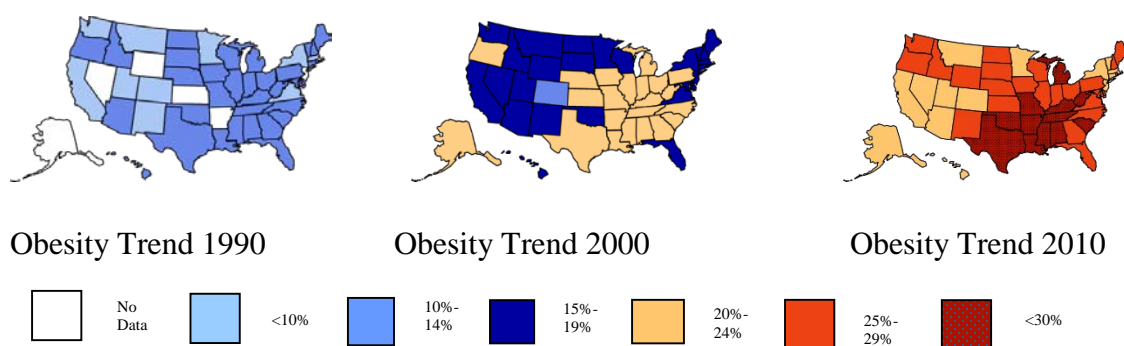
Source: Behavioral Risk Factors Surveillance System, CDC

Environmental Benefits

      Developmental choices also contribute to Global Warming, an environmental issue that has very detrimental effects on the environment and economy has a whole. The recent events and degree of destruction witnessed by Hurricane Sandy in late October 2012 has once again highlighted the impact of global warming. Nations around the world

are implementing measure to curb their output of greenhouse gases (GHG), which

contribute to global warming. The warming of the Earth's atmosphere is attributed to

certain gases that stay in our environment and act as a blanket, trapping heat generated

from the earth in and not allowing warming gases to escape. This in turn causes

temperatures to rise. Not all GHG are bad; without them the Earth's temperature would

be significantly lower, making for a dramatically different type of environment. The main

GHG are water vapor, carbon dioxide (CO_2) and methane. Of the three main gases

carbon dioxide is the one countries, cities, and states are effectively trying to reduce.

Carbon dioxide levels have continued to rise over the last one hundred years and will

continue to rise long after people implement drastic measure to limit their output into the

atmosphere.

   The consumption of fossil fuel energy is the single largest contributor of

greenhouse gas emissions for the world and carbon dioxide is responsible for 81% of

total U.S. greenhouse gas emissions (EIA, 2009). The number one contributor of carbon

dioxide emissions is transportation, which is closely tied to development, especially

sprawling green field developments. In the United States transportation accounts for

about 33% of total U.S. energy related GHG emissions, followed by the residential and

commercial sector with 26% of the emissions. The residential, commercial, and

transportation sectors combined account for close to sixty percent of GHG emissions, and

indicate the need for change in the way we travel and how we live (EIA, 2009). These

figures were obtained from the Department of Energy's Energy Information

Administration (EIA), Green House Gas Emissions Report, 2008. Data from the report

indicates an overall decrease in 2008 GHG emissions by 2.2 percent from 2007 totals. A

combination of factors contributed to the lowering, the economic recession and increase

in fuel prices, causing consumers to tailor back their usage.

The urgency in reducing greenhouse gases, especially carbon dioxide is

increasingly becoming more important to the overall functioning of the State of

California. The state realizes the economic, social and global importance of tying to

mitigate the effects of global warming. Part of this commitment is directly tied to

modifying current building practices and energy consumption which contribute

significantly to global warming. Urban and regional planning can encourage development

in ways that encourage walkable communities or continue with developments that

essentially assure dependence on auto use.

California has been a leader in support of recognizing and seeking solutions to

mitigate decades of misguided transportation and planning policy. Historical legislation

passed such as AB 32 - The Global Warming Solutions Act and SB 375 - The

Transportation and Land Use Planning Bill set new goals for California to move towards

a sustainable future. According the Office of the Governor Fact Sheet on SB 375, "SB

375 provides incentives for creating attractive, walkable, sustainable communities and

revitalizing existing ones. It will encourage the development of more alternative

transportation options. By doing so, this law will promote healthy lifestyles…

(www.gov.ca)." Due to these key pieces of state legislation, communities finally have to

adopt long ranging planning and development plans that are sustainable and

fundamentally smarter for society in the long term.

The next section will discuss the hedonic price model. This is important to explain

how a home's value is determined. An understanding of the model is needed to explain

why walkability should be part of home valuation.

Hedonic Price Model

Hedonic Model

There are a number of factors that affect the price of a home such as location,

housing characteristics, and land prices, to name a few. One can think of a house as a

basket containing many goods. Each of the goods plays a part in determining the basket's

value. Economic research on home values often use a method of "hedonic" home

valuation developed in the 1970's by Rosen (Gibbons & Machin, 2008). The hedonic

prices modes use a statistical regression analysis to arrive at a value for a home. This

statistical analysis determines home value derived from other variables and their

influence or impact on value. The hedonic framework in housing analysis is a useful tool

to determine the value of various housing characteristics and their impact on price.

Housing is not a uniform good, and simply comparing prices would not capture site

specific attributes that play a part in price (Cotright, 2009). Hedonic analysis essentially

unbundles the various components of a home and estimates a price for each; the value of

the house is a composition of the various characteristics (Rosen, 1974). House price can

be seen as function of some basic components, such as structural characteristics which

include number of bedrooms, number of bathrooms, age and lot size (Cotright, 2009).

Neighborhood characteristics include distance to school, transportation accessibility,

environmental factors, crime, and other location factors which can all influence the value

of a home. (Gibbons & Machin, 2004).

Some of the more widely studied effects on housing price include evaluation of

schools, transportation and crime. A review of the literature on these aspects undertaken

by Gibbons and Machin (2008) aimed to determine components of these characteristics

on property values. They show quality schools generally have a positive influence on

home price, but the degree of the influence varies across the 14 studies included in their

review. Magnitudes on home value from the studies range from a low of 1.3 percent

increase for one-standard deviation increases in math scores to a high of a 10 percent

increase for one-standard deviation of a school receiving and 'A' grade. The author's

own study in 2006 results in a 3.8 percent increase in home value for a one-standard

deviation increase in school performance (Gibbons & Machin, 2008).

Transportation accessibility was also found to be a key component of property

value. The closer a home is to transportation connections or rail transit the greater value.

Home within walking distance to rail and transit lines are valued at a premium. The

Gibbons & Machin study found a 7-20 percent decrease in home value for one-standard

deviation increase in home distance to transit station (Gibbons & Machin, 2008). The

authors also cited another significant study by Armstrong and Rodriguez (2006)

indicating a 10 percent premium for properties within a ½ mile of station and a 15

percent reduction in home value per minute with increasing home-station drive time (Gibbons & Machin, 2008).

The impact on housing values due to crime seems intuitive: the more crime in the area where a home is located, the less the value of that home. One study conducted in New York City determined that a fall in violent crime rates by 13% does in fact lead to about an 8% increase in property values. These values were statistically significant with 81% of the variation in home prices explainable by the model (Schwartz, Susin and Voicu, 2003). The period for the study is somewhat dated: property values and crime statistics were gathered in a ten-year period from 1988-1998. However, the indications from the study remain valid.

Neighborhood Characteristics

In addition to the hedonic price model there are factors related to community characteristics and design elements that influence housing price. These characteristics are not part of the variables I will use in my regression, but their importance stems from elements contained in their characteristics that encourage walking as a viable alternative to auto dependence.

Several studies by Tu and Eppli (1999, 2001) have analyzed the degree of price premiums for "New Urbanist" housing versus related suburban housing. In their study in Kentlands, Washington D.C it was shown that price premiums from 4% to 15% could be placed on housing in New Urbanist communities. Some of the features of New Urbanist communities include connected streets, higher densities and a mix of land uses, which

can also be attributes of a walkable community (Cotright, 2009). New Urbanist

communities are designed with the principles of traditional neighborhood development

(TND) and in this study the measure of New Urbanist and TND are used interchangeably.

New Urbanist communities in the study were identified with the dummy variable TND

and coded 1 if the development is a TND and 0 otherwise. The values from the regression

were then compared to a similar regression using conventional neighborhood data, with

conventional referring to low-density, auto-oriented development. Other relevant

variables from this study included age, total number of bathrooms, dummy variable for a

single story, and lot size. All were shown to be statistically significant in this study. Lot

size and number of bathrooms showed the greatest influence on home value besides the

TND variable.

　　　　Prior work also has found mixed-use land development patterns also have a

positive effect on home values. Song and Knapp (2003) conducted a study aimed at

addressing the lack of research that quantifies home values in mixed-use communities in

spite of popular claims of their benefits, and to determine consumer preference for mixed

used developments (2003). The study measured the proximity to amenities such as

shopping and parks. The authors found that housing prices increase when located near

public parks (.3%) or neighborhood scale commercial centers (1%), but decrease when

located near multi-family housing or bus stops. Most importantly, the study found that a

premium can be charged for housing located within walking distance of parks or

commercial centers. It should be noted also that the scale of commercial centers is

important, housing values decrease when the intensity of commercial centers increases,
there must be balance between housing and commercial space (Song & Knapp, 2003).

Walkability and Walk Score

I now turn to an assessment of studies where walkability is a key component or
explanatory variable for housing price. At this point I would like to explain the
components of walkability that determine a Walk Score™, which is central to my own
research. Walk Score is a value derived from the popular website, www.walkscore.com.
This measure uses publicly available data to allow one to look up a specific location's
walkability determined by distance from a specific location to nearby amenities.
Amenities are grouped and points are applied to the location based on the number of
amenities. Amenities a quarter of mile or less receive the highest points, with decreasing
points for increasing distances up to one mile. The categories are weighted and summed
providing a Walk Score value between 0-100, with 100 the best indicator of walkability.
An example of amenity categories includes restaurants, schools, parks, cultural centers,
etc. Walk Score also recently incorporated pedestrian friendliness by measuring
"population density road metrics such as block length and intersection density".
(www.walkscore.com).

In the past, the use of Walk Score in academic literature was limited and few
articles existed in peer-reviewed journals. However, there has been a change in the
academic scene and increasingly articles have appeared which have successfully
integrated Walk Score values into valid research. A question one must ask, is the use of

Walk Score a valid and reliable indicator of walkability and thus for this analysis, a

premium component of residential home value? So far the research has indicated yes,

Walk Score can be a useful tool and is a valid measure of walkable neighborhoods that

does translate to increased property values (Gilderbloom, Riggs, and Meares, 2015,

Duncan, et al., 2011, Carr, Dunsiger, and Marcus, 2010 and 2011) Its use in popular

home real estate websites such as Zillow.com and Realtor.com also attest to its

significance and use by the larger public (Leinberger, 2010).

In a very recent study published in February 2015, researchers questioned whether

walkability matter and sought to examine its impact on housing values, foreclosures and

crime (Gilderbloom, et al., 2015). The subject city for their analysis was 170 census tracts

in Louisville, KY considered to be a mid-size city. The researchers chose to use Walk

Score™ as their key test variable because of the following stated advantages "While

many tools employ surveys, self-reporting audits and observational data measures, the

Walk Score™ tool provides a direct and replicable way of assessing geospatial,

population and land use characteristics to benchmark walkability" (Gilderbloom, et al.,

2015, p. 16). This study also discussed the limitations with Walk Score™ which will be

analyzed further in theme four. Significantly, the research found that walkability is

valued and should be incorporated into hedonic regression analysis for mid-sized cities

where it has not been used, and is associated with higher property values, less

foreclosures and reduced crime rates. The researchers state the value from walkability

can influence policy toward creating sustainable neighborhood design and that is does

matter when consumers are evaluating where to live along with schools, jobs, crime, and transportation costs, (Gilderbloom, et al., 2015).

Christopher Leinberger, an author of several articles and books advocating for walkable communities, completed a coauthored study for the Brookings Institute on the walkability of places in Washington D.C (Leinberger and Alfonzo, 2012). The methodology for their research including trying to establish performance metrics for walkable urban places using a variety of secondary real estate, demographic, transportation, and economic data. The study's aim was to show that walkability could be a mechanism to increase a place's triple bottom line of people, planet, and profit. The study employed the use of Walk Score initially to determine walkable places in D.C. however do to limitations of Walk Score they ultimately used their own matrix based on are more complete set of micro-scale built environmental features which promote walking (Leinberger and Alfonzo, 2012). The limitations mentioned in this research and other research utilizing Walk Score will be discussed in more detail in the fourth theme of this literature review. The key finding in Lienberger's and Alfonzo's hedonic regression study was that residential rental units in walkable places can command an additional $301.76 per month in rents and for sale properties can add a $81.54/sq. ft. premium in value for a 20-point increase in walkability from a range of 94 (Leinberger & Alfonzo, 2012).

In another article researchers evaluated residential land values and walkability (Rauterkus & Miller, 2011). Walk Score was calculated for over 5,000 property

transactions and were evaluated in one county in Alabama to determine the relationship between residential land only values and walkability. This study is unique in that residential land values and not building improvements were analyzed using an OLS regression. The study found that controlling for population growth and lot size, walkability as measured by Walk Score did in fact have a direct relationship to land values. Land values in neighborhoods closer to the central business district (CBD), in older communities, and located near universities having a high degree of walkability which does increase land values (Rauterkus & Miller, 2011).

Another widely cited, non-academic study attempted to assess the impact of Walk Score on home values (Cotright, 2009). Most of the academic literature available had ignored walking as a form of transport in communities, and therefore the Cotright study is important and worth mentioning. The study obtained Walk Scores for 92,276 properties in 15 metropolitan cities in the United States and found that those properties with high Walk Scores are priced higher than a comparable home in 13 of the study cities (Cotright, 2009). The most Significant finding was that in a typical market a one-point increase in Walk Score translates to an increase of between $700 and $3000 in property value (Cotright, 2009). Yet the study is plagued by offering little methodological information, including how the properties and cities were chosen. While the study is suggestive, the results must be viewed with caution.

Another study use examines the impact of Walk Score on commercial property values and investment returns (Pivo & Fisher, 2011). According to the authors, an aspect

of sustainable and responsible property investing is the walkability of properties due to the inherent social and environmental benefits of building walkable places. The study used an OLS regression to evaluate the degree, if any, in which Walk Scores influence commercial property values. The study found that a ten-point increase in walkability increases property values between 1-9% dependent on property type, and walkable properties generate higher incomes (Pivo & Fisher, 2011).

Finally, one study examined the degree that walking influences social capital (Leyden 2003). According to the author, walkable communities encourage social cohesion, political participation and builds trust (2003). However, the study suffered from notable limitations, including a low response rate of the survey (279), which was designed to capture data on the key variables. In addition, respondents were asked to determine their walkability index based on a set of nine questions. Finally, the study took place in Ireland, which can hinder the results from being applicable to U.S. communities.

In summary, the studies of the walkability of a location seems to indicate that a premium in price is associated with walkability in commercial and residential markets as well as increasing social capital.

Walk Score Limitations

The Walk Score also has notable limitations. It does not account for other walkability factors such as safety, environmental, or topographic deterrence's (Gilderbloom, et al., 2015, Pivo and & Fisher, 2011, Carr, et al., 2010). Walk Score has

addressed the safety aspect limitation with its Crime Grade, but this is an independent measure and it is not calculated in the Walk Score algorithm.

Perhaps the greatest limitation, and one currently being addressed by Walk Score, is the straight line distance calculated from one location to another, not factoring in attributes that facilitate walking such as street connectivity and route. The website now has a beta version of what is called Street Smart, which calculates a Walk Score that takes into account street connectivity and intersection density for a specific location (www.walkscore.com).

Gilderblooms, Riggs, and Meares 2015 work in Louisville, KY highlight some of the previously mentioned limitations identified with Walk Score including the straight line distance calculations. This is an important aspect as people when walking do not always have the ability to walk the shortest route from point A to point B. This limitation was also identified in an article on the validation of Walk Score (Duncan, et al., 2011). The consensus from the research indicates Walk Score can be useful to determine some walkable places, but cannot be universally applied to measure overall neighborhood walkability (Duncan, et al., 2011). There are factors such a road routes and environmental features such as lakes or parks that determine one's route to a destination.

An additional limitation found with Walk Score was the fact that information obtained for determining amenities were drawn from publically available sources such as Google Maps which could potentially have geo-location errors and amenity classification errors because of user contributions. Walk Score states in the data methodology data is

compiled from Google, Education.com, Open Street Map, and from information added by

the greater Walk Score community (www.walkscore.com). An additional limitation with

the Walk Score data is the absence of street quality in the algorithm which does not

account for trees, places to sit, sidewalk width and overall aesthetic value of the walking

route (Gildberbloom, et al., 2015, Leinberger & Alonzo, 2012, Pivo & Fisher, 2011).

In the Brookings Institute study mentioned previously, researchers Leinberger and

Alfonzo (2012) initially used Walk Score in determining their walkable neighborhoods in

Washington DC but opted for a more detailed set of micro-scale walkability measures in

their study. Using the Irvine Minnesota Inventory (IMI) which is a 162-item audit tool

used to collect information on built environment characteristics objectively. The

researchers collected data from sample blocks in their neighborhood sets which rated

walkability on ten urban design elements:

1. Aesthetics (attractiveness, open views, outdoor dining, maintenance)

2. Connectivity (potential barriers such as wide thoroughfares)

3. Density (building concentrations and height)

4. Form (streetscape discontinuity)

5. Pedestrian amenities (curbcuts, sidewalks, street furniture)

6. Personal safety (graffiti, litter, windows with bars)

7. Physical activity facilities (recreational uses)

8. Proximity of uses (presence of non-residential land uses)

9. Public spaces and parks (playgrounds, plazas, playing fields)

10. Traffic measures (signals, traffic calming)

The urban design measures are not accounted for in Walk Score and provide a more robust measure of walkability from a walker's perspective. If the goal is to design neighborhoods and communities that facilitate walking Walk Score can be utilized as a starting point as Leinberger and Alfonzo (2012) did but then incorporate more features that assess the street, community, and neighborhood more completely.

An additional limitation identified with Walk Score is the fact that amenities are rated equally and no preference is given for frequency of use or for example a convenient store versus a grocery store which caters to different walkers and reasons for walking (Pivo & Fisher, 2011, Duncan, et al., 2011).

Taken as a total Walk Score is not a perfect measure of walkability. The fact is it is a fluid data set, being updated as continued research identifies limitations. The data itself is changing as environments change. Walk Score is, however, a useful starting point for some researchers, but there are other factors of walkability that should be measured when determining community walkability. I will return to the limitations of Walks Score in more detail in Chapter 5. , where I propose a new method of assessing walkability.

Chapter 3

REGRESSION ANALYSIS: WALK SCORE AND SACRAMENTO HOME SALES

PRICE

For the quantitative analysis portion of my thesis, I ran a hedonic regression

analysis using housing data from the Sacramento Area to try to tease out the influence of

the standard Walkability Score on the sales price of homes. This chapter summarizes my

methods. Specifically, I present my model and explain my choice of a dependent

variable, broad explanatory categories, and the specific explanatory variables in each

category. I then provide my regression results.

Hedonic Regression Model

I estimate the following derived regression equation using the Original Least

Squares (OLS) estimator technique which enables a determination of the relationships

between the dependent variable and an explanatory independent variable, holding other

explanatory variables constant.

The reason for using OLS is to derive numerical values for dependent and

independent variables for an otherwise theoretical concept and equation. This is an

important point for consideration, since this regression analysis will be using limited data

(Sacramento City home prices as a function of walkability) to explain a concept that

could be applied more broadly. It is important to know how well the estimated data will

fit the actual data. OLS regression also minimizes the difference between actual data and

estimated data, ensuring a more real world estimate of a given sample.

Home Price

The dependent variable used in this regression model is 2008-2009 Sacramento City home sales prices drawn from Multiple List Serve and only for two specific zip codes in Sacramento which will be provided when discussing details of this variable. Home prices are reflective of a wide range of explanatory variables. I want to test the influence of the current way of measuring walkability on home sales price after doing my best control for other factors that could drive home price. The goal is to determine the value that people place on walkability (as currently defined and measured) when looking for a home. If the value is positive and statistically significant, then there is further justification for land use planning to stress this concept when designing new neighborhoods or retrofitting existing ones. Of course this finding is based upon the current way that walkabaility is accounted for.

Factors that Cause Differences in Home Prices

This research seeks to determine if there is a correlation between differences in housing price and walkability. In order to do this, I need to account for the other factors that drive home prices. The broad categorical factors expected to cause variation in housing price are: (1) walkability index, (2) home size characteristics, (3) home structural characteristics, (4) home age characteristics, (5) neighborhood characteristics, and (6) location. The variables I specifically use to measure all of these broad causal factors are

given next with a designation of (+), (-), or (?) included after each variable to indicate the

anticipated direction the variable have on sales prices.

Where:

Walkability Index= f [Walk Score (+)],

Home size characteristics = f [house square feet (+), lot square feet (+)],

Home structural characteristics = f [number of bedrooms (-), number of full bathrooms (+), number of half bathrooms (?), presence of a garage (+), presence of a pool (?)],

Home Age Characteristics = f [house age (-), years since home remodel (+)],

Neighborhood Characteristics = f [homeowner association (?), bank owned property (-), per capita income by zip code (?), percent of adult population below federal poverty level by zip code (-)],

Location = f [set of zip code location dummies with 95816 excluded (?), population density by zip code (+)]

The specific variables for each broad category were chosen for this research due

the assumption that they would have the greatest influence on the dependent variable and

from previous research analyzing home price. I offer specifics on my choice of variables

next.

Walkability Index

The Walkability Index contains a specific variable Walk Score determined by

using the website www.walkscore.com to obtain a score for each address included in the

study. The values assigned to each location range from 0 to 100. Location values are

additionally categorized within five categories: 0-24 Car Dependent, 25-49 Car

Dependent, 50-69 Somewhat Walkable, 70-89 Very Walkable, 90-100 Walker's Paradise

(www.walkscore.com), for the purpose of this research on the score is used not the categorizes. The values obtained from the website indicate each specific home's proximity to nine amenity categories: grocery stores, restaurants, shopping places, coffee shops, banks, parks, schools, libraries and other places with access to books, and places of entertainment. The destination categories were selected based on available research indicating these places are walked to the most or considered drivers of walking. Grocery stores and restaurants/bars destinations receive the greatest weights based on studies indicating their importance (Walk Score Methodology, 2011).

As stated previously, a Walk Score is not a perfect measure of walkability due to limitations in how distance is measured and other variables that influence walking such as crime and safety; however, obtaining a Walk Score is free and it has been demonstrated in the literature to be a reliable and valid measure of walkability. Walkability is anticipated to have a positive effect on home value and is based on research and indicators in other metropolitan housing markets that there may be pent-up demand in walkable urban communities. In a variety of coast to coast urban markets the price per square foot of urban housing can carry a price premium of forty to two hundred percent more than traditional suburban housing, but only five to ten percent of housing stock is located in walkable places (Leinberger, 2008). Based on research there is a limited supply of housing in walkable urban places and increased demand created by changing demographics, environmental, and health concerns. This demand creates a greater value for housing in walkable communities. This is evident in Sacramento, where

downtown and midtown properties rent and sell for more than in some outlying suburban areas.

Home Size Characteristics

Home size characteristics include measures of home size in square feet and lot size in square feet; both are a considered a significant part in determining housing price. This is based on the assumption that a house with more square feet and a larger lot can command more in the housing market. As stated, housing characteristics can be a considered a bundle of variables which make up price. Larger homes require more land, materials, and overall increased building costs, and as such are reflected in home price.

Home Structural Characteristics

Home structural characteristics include features that influence prices such as number of bedrooms, number of full bathrooms, number of half bathrooms, whether a home has a garage, and whether a home has pool. The two features expected to have a positive influence on price are number of full bathrooms and having a garage. Number of bedrooms decreases the amount of communal space in a home and is considered to have a negative influence on price. The last two variables to have an undetermined effect on home value are having a pool and the number of half bathrooms. I consider these preferences and may seem desirable to some people, but not to others, and therefore an anticipated effect on home value cannot be stated.

<u>Home Age Characteristics</u>

Home age characteristics variables contain data on home age and years since a remodel. The older a home the less value it is anticipated to have, but a home remodel should have a positive effect on price. Older homes can require more maintenance and servicing. The potential for things to go wrong increase in an older home versus a newer built home. There is some evidence that points to inherent value placed on historical or older homes; however generally speaking older homes have less value. Homes that have gone through a remodel should in theory increase in value. This is providing the remodel was relatively recent; a forty-year old remodel of a one-hundred-year old home would not be considered recent or value adding.

<u>Neighborhood Characteristics</u>

There are many attributes of a neighborhood. For the purpose of this research neighborhood characteristics considered to influence home value are: belonging to a homeowner's association, if a home is banked owned, the percent of the population in poverty, and the per capital income of the neighborhood. It is undetermined if homes belonging in a homeowner association positively or negatively influence price. Some people may like the sense of security and other amenities that belonging to an association can provide, to others having to pay into an association may not seem appealing. A dummy variable indicating homeowner association evidenced by HOA fees is included to indicate this neighborhood characteristic.

The foreclosure crisis affecting many places in the nation has highlighted the detrimental effects of declining property values on communities. Places with a far number of bank owned properties have had to deal with among other things crimes of vandalism and theft, sketchy characters moving in, gangs and poorly maintained vacant properties (Leinberger, 2008). These characteristics portray a neighborhood in disarray with a multitude of social problems effecting communities all over the country. Sacramento area suburban communities have not been immune to the foreclosure crisis. Communities in suburban areas like Elk Grove and Natomas have been especially hard hit with plummeting home values and foreclosures. A dummy variable for Real Estate Owned (REO) indicates bank owned foreclosed properties and for the reasons stated previously is indicated as having a negative correlation to home price.

The final two variables indicating poverty and per capita earnings are included to provide socio-economic demographics of the communities included in this research. The poverty variable is a measurement of the percent of the community living below federal poverty level. This variable was determined to have a negative association with home value. The rationale behind this assumption is based on presuming people would not prefer to live in places where a significant percent of the population was living in poverty. The last variable is a measure of the per capita earnings of the communities. Per capita income is calculated by dividing the mean income received for the past year by all inhabitants of a community by the total population of that particular community or geographic location (www.census.gov). Per capita income is a variable of socio-

economic status (SES) and assumes to have a positive association on home value for the communities analyzed in this research.

Location Characteristics

Two dummy variables representing the Sacramento City zip codes of 95816, and 95831 were created to indicate the geographic location of the home sale data used as part of this research. The zip codes were chosen to represent a mix of urban and less urban locations in Sacramento with contrasting walkability features and home sales price as a reflection of demographic and neighborhood differences and distance to the central business district. The following table categorizes the zip codes based on the corresponding features. Overall it cannot be determined what direction the individual zip codes will have on home sale price.

Table 2. Sacramento Zip Codes

SACRAMENTO ZIP CODES	
Urban zip code (walkable, close to CBD)	95816
Less urban zip code (less walkable, greater distance to CBD)	95831

The final variable included under location is the population density of the individual zip codes used in this research. Population density was included to show how many people per square mile live in the communities where home sales data was obtained. Population density is included as a factor that influences home price.

Data Sources

I used three data sources in my research. This section provides detailed information on the data sources and selection. A thorough understanding of the data used in this regression model is imperative to understanding and interpreting the results. Additional importance in providing data detail is to enable research duplication, a key step required of sound research and policy assumptions. This chapter concludes with the collection and organization of the data displayed in table format to allow ease of analysis.

Homes Sales Data

Home sales price in the years 2008-2009 obtained through the Multiple List Serve (MLS) provided most of the data used in this regression analysis. The dependent variable of home sale price or PRICE was sorted from the file to only include sales data on the communities analyzed. The mean home sales price for the research area was $224,171 and values ranged from a very low $6053 to a high $1,550,000. Three of the six broad independent variable categories; Home size characteristics, home structural characteristics, and home age characteristics were exclusively obtained from the home sales data. The mean house size in square feet was 1501 and the mean number of bedrooms was three, mean age was slightly more than 43 years. Neighborhood characteristics contain the two dummy variables of HOA and REO obtained from the home sales data. Additionally, two zip code dummies were created from the home sales data and homes sales prices were grouped by the two zip codes of 95816 and 95831.

Walk Score Data

The key explanatory variable is a *Walkability Index* as defined by Walk Score. A total of 463 Walk Scores were obtained on home sale locations in the 95816 and 95831 zip codes. The key variable WALK provides a walkability proxy for the two zip codes. Taken together the zip code variables represent walkability as a function of home price in the selected areas. The rationale for the selection of the zip codes represent a desire to analyze the effect of walkability of areas with varying degrees of home price and neighborhood characteristics. The mean Walk Score for the research area was 51 indicating a "somewhat walkable" category, with values ranging from zero "car dependent" to 92 "walkers paradise" (walkscore.com).

Census Data

The remaining variables used in the regression analysis were obtained from U.S. Census data, specifically recently released (December, 2012) 5-year estimates of American Community Survey (ACS) data for the years 2007-2011. ACS data is an ongoing yearly survey from communities that provides statistical information used to determine federal and state funds allocations for specific investments and services (www.census.gov). ACS 5-year estimates are the best for analyzing very small populations with the largest sample size. These estimates are more reliable than 1-year and 3-year estimate released by the ACS. The geographic location analyzed from the ACS 5-year estimates is what is known as ZCTA's or Zip Code Tabulation Areas. Zip Codes and Zip Code Tabulation Areas differ in that postal delivery routes use zip codes,

and the Census Bureau creates ZCTA's as approximate areas corresponding the U.S.

Postal Service 5 digit zip code service areas (www.census.gov). For this regression

analysis ZCTA's correspond most closely with the zip code areas collected for home

sales, and their use provides the latest and most reliable demographic information

released by the Census Bureau. ACS data included in this regression analysis is

categorized by the four ZCTAs corresponding the 95816 and 95831 zip codes and is

summarized in the following table.

Table 3. American Community Survey 5-Year Estimate Data

	ZCTA5 95816		ZCTA5 95831	
Variable	Estimate	%	Estimate	%
Total Population	16,195		41,345	
Population Density	7789.5		5903	
Per Capita Income	$41,143		$38,221	
Persons below poverty	1,891	12.0%	2,912	7.1%

Source:2007-2011 ACS 5 Year Estimates, 2012

Table Descriptions and Statistics

Following are two tables containing various information regarding the

independent variables. Table 4. contains information on variable names, a brief

description of the variables and data source. Table 5 contains more descriptive level data

including the mean, and the maximum and minimum values for each variable.

Table 4. Variable Labels, Description, and Data Source

Variable Name	Description	Source
Dependent Variable		
PRICE	2008-2009 Sacramento, CA homes prices in two zip codes	20082009SacAreaHomeSales.xls file accessed ww.online.csus.edu/webct
Explanatory Variables		
WALK	Walk Score for select homes in two Sacramento, CA zip codes	Walk Scores obtained from website www.walkscore.com
House Size Characteristics		
HMSIZE	Size of home measured by square feet	20082009SacAreaHomeSales.xls file accessed ww.online.csus.edu/webct
LOTSIZE	Lot size of home measured by square feet	20082009SacAreaHomeSales.xls file accessed ww.online.csus.edu/webct
Structural Characteristics		
BEDRMS	Number of bedrooms	20082009SacAreaHomeSales.xls file accessed ww.online.csus.edu/webct
FBATH	Number of full bathroom	20082009SacAreaHomeSales.xls file accessed ww.online.csus.edu/webct
HBATH	Number of half bathrooms	20082009SacAreaHomeSales.xls file accessed ww.online.csus.edu/webct
DGARAGE	A dummy variable indicating if home has a garage	20082009SacAreaHomeSales.xls file accessed ww.online.csus.edu/webct
DPOOL	A dummy variable indicating if home has a pool	20082009SacAreaHomeSales.xls file accessed ww.online.csus.edu/webct
House Age Characteristics		
AGE	The age of the home	20082009SacAreaHomeSales.xls file accessed ww.online.csus.edu/webct
REMODEL	Years since home remodel	20082009SacAreaHomeSales.xls file accessed ww.online.csus.edu/webct
Neighborhood Characteristics		
DASSOC	A dummy variable indicating HOA dues	20082009SacAreaHomeSales.xls file accessed ww.online.csus.edu/webct

DREO	A dummy variable indicating a bank owned property	20082009SacAreaHomeSales.xls file accessed ww.online.csus.edu/webct
PERCAPINCZC	The per capital income for a particular zip code	2007-2011 American Community Survey-Community Profile
%POPBPOVZC	The % of the adult population living in poverty by zip code	2007-2011 American Community Survey-Community Profile
Location		
D95816	A dummy variable indicating if home is located in 95816 zip code	20082009SacAreaHomeSales.xls file accessed ww.online.csus.edu/webct
D95831	A dummy variable indicating if home is located in 95831 zip code	20082009SacAreaHomeSales.xls file accessed ww.online.csus.edu/webct
POPDENZC	The population density by zip code	2007-2011 American Community Survey-Community Profile

Table 5. Descriptive Statistics

Variable Label	Mean	Std. Deviation	Minimum	Maximum
Dependent Variable				
PRICE	$224,171	141921.042	$6,053	$1,550,000
Independent Variables				
WALK	51.23	16.786	0	92
Home Size Characteristics				
HMSIZE	1501.56	531.723	498	5583
LOTSIZE	6145.61	2789.018	0	28401
Home Structural Characteristics				
BEDRMS	3.08	.804	1	9
FBATH	1.84	.583	1	5
HBATH	.24	.430	0	2
DPOOL	.12	.328	0	1

DGARAGE	.88	.328	0	1
Home Age Characteristics				
AGE	43.11	29.301	4	132
REMODEL	.25	1.277	0	11
Neighborhood Characteristics				
DASSOC	.11	.311	0	1
DREO	.59	.492	0	1
PERCAPINZC	$28,875	6614.098	$21,892	$41,143
%POPBPOVZC	15.80	8.268	7	31
Location				
D95816	.09	.279	0	1
D95831	.19	.395	0	1
POPDENSZC	5523.577	853.0350	4843.2	7789.5

Chapter 4

FINDINGS AND INTERPRETATIONS

In the previous chapter I formulated a theoretically sound model of the regression

equation I wish to estimate. Furthermore, I have the data needed to estimate this

regression and I have anticipated the effect I expect each of the explanatory variables in

the regression model will have on home value. I offer the result of the regression analysis

in this chapter, as well as a discussion of previous findings. This chapter specifically

contains: (1) an overview of the initial regression, (2) a comparison and selection of the

ideal functional form which best represents the data, (3) the steps required to check for

errors in the equation, (4) a discussion of remedies for any such errors, and (5) an

analysis of the updated regression results. This chapter concludes with a discussion on

how the results obtained from this research compare to other findings.

Initial Regression

The basis for the rationale for initiating a regression analysis was not to make a

prediction on the relationship between Walk Score and home sales price, but rather to

determine, and then analyze, what degree, if any, the Walk Score variables had on home

sales price. From the start my research has focused on determining the impact of Walk

Score on home sales price with the objective of determining if Walk Score is a good

measure of walkability.

For a regression analysis to be valid it must adhere to certain assumptions. In part,

this chapter checks for the adherence of these assumptions. The very first assumption

being there must be a linear relationship between the dependent and key independent

variables. In this research it is 2008-2009 Sacramento City home sales prices drawn from Multiple List Serve for two specific zip codes 95816 and 95831 and the corresponding Walk Scores for the homes sold for the given years. The following diagram illustrates the expected linear relationship between the log of homes sales price (my dependent variable) and Walk Score (my key explanatory variable).

Figure 2. Scatterplot Linear Relationship

Linear Relationship Between Homes Sales and Walk Score
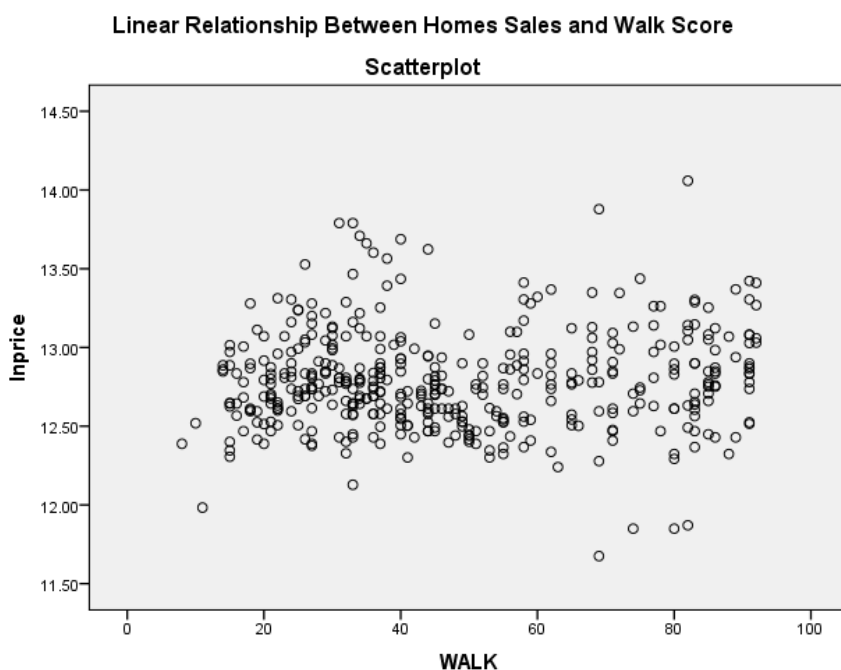
Source: SPSS V.22

The mostly linear relationship indicated in Figure 2 shows visually it is safe to proceed with the regression analysis. The second assumption of a valid regression is there must not be significant outliers in the data set that could potentially influence or skew the data. As shown in the diagram there are outliers. These outliers do not skew the data but were double checked to ensure there were not data entry errors.

I conducted many different regression analyses to determine which functional form best fit the data. The regression results recorded below represent the final result of these tests, using various forms of some of the independent variables. It is worth noting this at this point to validate the selection of the chosen variables. Additionally, this thesis builds upon previous work I completed on a similar regression model. In this previous analysis I used only data from the 95816 zip code in the Sacramento Area. In this regression analysis I added data from the 95831 zip code which includes the Greenhaven-Pocket area of the southern part of Sacramento, neighborhood per capita income, population density and persons in poverty are calculated by zip code, the inclusion of the 95831 zip code dummy will need to proxy for these. The regression coefficient on the 95831 dummy variable measures the expected difference in home prices in this neighborhood as compared to the excluded neighborhood with a zip code 95816.

The following Table 6 presents the estimated coefficients of home value as a function of the various explanatory variables with a total of 433 observations. Table 6 includes the various functional forms of the regression analysis as well as the preferred functional form with Variance Inflation Factors (VIFs) calculated to aide in the evaluation of possible errors. In parenthesis are the p values for each regression coefficient. These values must be below 0.10 for the relevant explanatory variable to exert an influence on home on price that is statistically significant from zero. Note also that next to each explanatory variable name in the first column of Table 6, in parentheses, is an indication of whether the variable could be logged in one of the different regression

forms I tried. Additionally, and also in parentheses, the table includes the effect I

expected this variable to have on home value.

Table 6. Regression Results Comparison of Functional Form

Variable Label (ln=log form)^	Log-Log	Linear-Linear	Log-Linear	VIFs Log-Linear
CONSTANT	12.585 (.000)*	160974.819 (.000)*	**12.307 (.000)***	
WALKSCORE (ln) (+)	.013 (.610)	-11.203 (.966)	**.000 (.706)**	**3.809**
D95831 (-)	-.469 (.000)*	-166542.613 (.000)*	**-.402 (.000)***	**6.400**
[1]D95816	NA	NA	NA	NA
HMSIZE (ln) (+)	.548 (.000)*	128644.119 (.000)*	**.295 (.000)***	**3.715**
LOTSIZE (ln) (+)	.168 (.000)*	6385.367 (.000)*	**.014 (.000)***	**1.859**
BEDROOM (ln) (-)	-.017 (.726)	-1523.112 (.791)	**.001 (.928)**	**2.447**
FULLBATH (ln) (+)	.114 (.014)*	28885.461 (.002)*	**.053 (.037)***	**3.444**
HALFBATH (+/-)	.008 (.695)	19881.888 (.825)	**.010 (.628)**	**1.314**
DPOOL (+)	.033 (.135)	11249.613 (.164)	**.041 (.064)***	**1.143**
DGARAGE (+)	.061 (.072)*	27096.482 (.029)*	**.102 (.003)***	**1.528**
AGE (ln) (-)	-.057 (.016)*	212.318 (.192)	**-.001 (.250)**	**4.010**
REMODEL (+)	.006 (.057)*	3140.454 (.008)*	**.007 (.038)***	**1.047**
DASSOC (+)	.141 (.000)*	50892.675 (.000)*	**.081 (.014)***	**1.396**
DREO(-)	-.226 (.000)*	-82945.896 (.000)*	**-.227 (.000)***	**1.048**
R-Squared	.683	.747	**.682**	

Adjusted R-Squared	.673	.740	**.672**	
Observations	433	433	**433**	

*Significant at the 90% level, (all two-tailed test)
^ Variables logged in the log-log form are indicated with a (ln).
[1]D95816 was excluded from analysis.

Selection of Functional Form

The initial regression functional form I chose was log/semi-log equation. This means the dependent variable was in log form, and where possible, some of the explanatory variables were also in log form. This form estimated nine significant variables. The second functional form used is linear-linear and this yielded eight significant variables. The final regression was run in log-linear form and as with the log-log forms, estimated nine significant variables. Significant variables were determined at the 90% confidence level (p value < 0.10). Of the nine significant variables, eight were significant across all three functional forms; the AGE variable was only significant in the log-log form. The Walk Score variable was not significant in any of the forms. A new interaction variable of log Walk Score times log Walk Score was also attempted and was included to determine if it would become significant; it was not. As a result of the data analysis it was determined the log-linear provided the best functional form. I selected this form for a variety of reasons. One is the number of significant variables with predicated influence. Also note that the calculated variance inflation factors, all being less than seven, indicate that multicollinearity is not likely to be a problem that would cause some explanatory variables to be determined to not exert an influence on the dependent variable.

Also of importance, the log-linear form allows for a simple method of interpreting the results. Specifically, the dependent variable is reflected as a percentage change as a result of a change in the independent variables (Studenmund, 2006, p.215). Put another way, for each independent variable, a one-unit change corresponds to a percent change in home value. For example, the coefficient for REO is -.227 significant at the 90% level, which means for a one-unit increase in REO, home value decreased by 22.7 percent. In addition, a review of the histograms for the dependent and key independent variables in the various forms log and linear, showed skewness. Specifically, the Walk Score coefficient in the log form was negatively skewed and the linear form of the PRICE variable was positively skewed. Using the log-linear functional form accounted for the skewness and mitigated the effect of the final regression analysis.

The R-Squared values reported at the bottom of Table 4 above indicate the percentage of variation in the dependent variable from the mean that is explained by the explanatory variables. Higher R-Square values are desired due to their indication of a "better fit" model, that is the explanatory variables more meaningfully explain the dependent variables. However, overall fit is not the only important component of a regression analysis. The R-Square value for the log-linear form did not yield the highest numbers especially when compared with the linear-linear form but they are not directly comparable across regression functional forms that take the log of the dependent variable and do not do this. Other factors, such as the degree of fit with economic theory and assumptions indicated by the data and model are equally, if not more important than high R-Square values (Studenmund, 2006, p. 59).

Regression Analysis Errors

Ordinary Least Square (OLS) regression analysis is the model chosen for the econometric estimation of home value as a function of various explanatory variables. This regression analysis attempted to estimate the degree of walkability on home value in two Sacramento zip codes. That is, OLS regression provides a sample estimate of a true population (Studenmund, 2006, p. 37). OLS regression is the model of choice due to its relative ease, but there are several classical assumptions that must hold for OLS to be a preferred regression technique. Part of ensuring a valid and significant model is to minimize and or correct for violations of assumptions. Two important assumptions that are often violated in cross-sectional data analysis are multicollinearity and heteroscedasticity. Multicollinearity simply means two variables are almost perfectly linear with each other leading to problems with the regression model and heteroskedasticity means the variance of residuals are similar to the predicted values.[1] The following sections on Multicollinearity and Heteroskedasticity outline the steps taken to reduce violations of these classical assumptions as well correcting for any errors.

Multicollinearity

Multicollinearity leads to problems of knowing which variable exerts the greatest influence on the dependent variable. To test for multicollinearity, a two-step process was performed on the regression model. The first step involves reviewing bivariate correlations.   An 80 percent and above threshold are a clear indication of

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[1] (Introduction to SAS. UCLA: Statistical Consulting Group from
http://www.ats.ucla.edu/stat/sas/notes2/ accessed July 15, 2015).

multicollinearity. This analysis did indicate relationship values greater than 80 percent and for this reason is what excluded from all model tests. The Census information removed were the population density, persons below poverty, total population, and per capita income. The second step to check for multicollinearity involves obtaining VIFs for all the explanatory variables used in the final regression equation. The threshold for VIFs to indicate multicollinearity is 5. VIFs greater than 5 indicate that one explanatory variable could be explained by all other variables. It does not single out the relationship as the bivariate correlation does, thus the need for the two-step process. As presented in Table 4 the D95831 coefficient is the only value exceeding 5, but it was found to be statistically significant (the problem that multicollinearity causing that it biases the finding toward not being statistically significant) and thus there are no issues with multicollinearity in this analysis.

Heteroskedasticity

A second classical assumption violation prevalent in cross-sectional research is heteroskedasticity. This occurs when the variance of the error term is not constant due to a wide variation in the values of the observed dependent variables (Studenmund, 2006, p.348). Heteroskedasticity in of itself does not bias the coefficient estimates. However, its presence will tend to underestimate the variance and standard errors making t-scores and hypothesis testing unreliable. A series of steps in the regression analysis is required to check for and correct heteroskedasticity. Prior to starting the Park Test to check for heteroskedasticity in the equation, weighting of the variables HMSIZE and LOTSIZE was done to control for wide variances in these observations.

The Park Test involves taking a final regression with the best functional form and obtaining residuals or estimates of the error terms. Once the residuals are obtained, they are squared then logged. The log of the square residuals is then tested in a second regression as the dependent variable. The explanatory variable or suspected proportionality factor Z variable is logged and is tested in the second equation as the only independent variable. For this analysis, home size in square feet was determined to be the Z factor due to suspected significant variation within the observations. An additional step in the analysis finds the t-test to be statistically insignificant. The null hypothesis of homoskedasticity may not be rejected as the absolute t-score [-1.384] is less than the critical t-value 1.645 (10% level of significance two-tailed test, 474 degrees of freedom) further indicating no significant conditions to correct for heteroeskedasticity.

Discussion of Findings

Model Fit

A reflection on the model is required at this point to access the quality of the regression equation as well as discuss how well the OLS model fits the data. The R-square value is a good starting point to begin this analysis as it is referred to as the coefficient of determination. The R-square value provides a percentage that indicates how well the dependent variable is explained by the regression equation. Values for R-square range from 0 (indicating a poor fit) to 1.0, (indicating a perfect fit). The R-square value from this research is .682 indicating 68 percent of the regression model fits or explains home values. While this is not a relatively high value it does provide a starting point to

expand or change the research. It is possible that some key explanatory variables ae missing, suggesting the existence of omitted variable bias.

<u>Expectations and Significant Variables</u>

As noted in the Model section of this report and presented in Table 4, most of the variables had the expected coefficient influence. Seven variables D95831, DGARAGE, FBATH, HMSIZE, LOTSIZE, REMODEL, DASSOC, and DREO are found to be significant at the 90% confidence level; DPOOL was significant only in the log-linear model. As indicated previously no interaction variables of Walk Score and zip code were used in this research which does contrast with the prior research where a MIDTOWNWALK coefficient was used in the final design model. These interaction variables were not statistically significant in any form. Taking note from this prior research it was shown this interaction variable may not be as well of an indicator of walkability and home value in midtown Sacramento. Expanding on that this thought the SUBURBWALK variable would also not be a good indicator of walkability and home value in the suburban fringe of Sacramento. Prior research indicated the MIDTOWNWALK variable should have been dropped from the equation and this study made note of this.

New Walkability Measure

This chapter has demonstrated that although the regression analysis presented here can be reliable and thus valid research, it is still not fully representing the value of walkable communities. My analysis demonstrated that despite the multiple attempts to incorporate Walk Score as an influence on home price, it was not shown to have an impact. I propose

using a method similar to Leinberger and Alfonzo in their evaluation of Washington D.C.

Similarly Walk Score data was obtained for neighborhoods, this data was then broken

down further to analyze micro level neighborhood characteristics that support walkability

(Leinberger and Alfonzo, 2012). In the final chapter I will review the regression model,

discuss some of its limitations and discuss why these limitations necessitated the need for

a more robust research model. Specifically, the final chapter will expand on the

walkability model I suggest can be used in conjunction with the regression analysis

presented thus far with the ultimate goal of contributing to the research agenda of

sustainable community design. It is important to keep the underlying importance of

walkability always at the forefront, to develop research that helps to support the

development of sustainable communities that are healthy, vibrant, and good for the

planet.

Chapter 5

AN ALTERNATIVE WALKABILITY MEASURE

As my thesis concludes, I am once again faced with answering the big questions:

Why are walkable communities important and can the current measures of walkability

truly assess the value of neighborhood sustainability?

In the first chapter of this thesis, I explained that walkable communities offer the

beginnings of creating sustainable communities. Once value is added to a place because

of the mere ability to walk from point A to point B, it can perhaps be a driver of other

sustainable features such as a more health environment and perhaps a generator of social

capital. Sustainable communities can both be economically vitality and not impose

negative external effects on other communities. The more that some communities can

adopt a model of sustainability, of which walkability is an essential part, they become a

beacon for other communities to follow.

Chapter 2 provided a brief summary of some of the relevant research on

walkability. I presented information from a health and social perspective on why creating

healthy, vibrant communities can be a way for communities to combat growing rates of

obesity from sedentary lifestyles. Creating walkable communities can be one part of

solving the problem by giving individuals the option to live in less car dependent

communities. Chapter 2 also provided the background on other research that employed

the use of Walk Score data. The relevance of Walk Score data in research was found to

be valid for some purposes and therefore had policy implications. For instance, a study

conducted using data from Louisville, Kentucky in year 2015 found Walk Score to be

replicable for assessing the walkability of a location and more walkable locations do translate into higher property values, less foreclosures and less crime (Gilderbloom, et al., 2015). An additional study from Alabama in year 2011 found Walk Score to be a good indicator of increased land values, specifically the study found places located in the central business district and with increased walkability did in fact increase land values (Rauterkus & Miller, 2011). The Pivo and Fisher (2011) study of 4,200 commercial properties around the country, from the years 2001 to 2008, employed Walk Score values in a regression analysis concluded property values increased anywhere from 1 to 9 percent for a ten point increase in walkability based on a 100 point scale .

Chapters 3 and 4 went into more detail about my own thesis research and methodology, as well as what specifically I was measuring and trying to convey. In summary, I described how I will employ a regression analysis on homes sales data and Walk Score data for Midtown and the Greenhaven-Pocket are of Sacramento with two very different perceived walkability. The goal was to determine if walkability influenced homes sales price, and if it did, by how much influence. The regression analysis explained 68 percent of the real-world variation in home prices from the two chosen Sacramento communities, but the Walk Score specifically was found to not have an influence on home value contrary to what was expected and found in previous research.

The results of the regression analysis suggest the need for additional analysis of the Walk Score data. The purpose of this concluding chapter will be to review the flaws with Walk Score as evidenced in my research and to propose a method for changing it. The remaining sections of this chapter will review Walk Score as it was used in the

regression and provide an explanation for why it is flawed. I will finally offer my suggestion for developing a walkability index that addresses the Walk Score shortcomings.

Walk Score Limitations

The concept of using a Walk Score to calculate the range of walkability for specific residential locations is potentially a great and useful tool for consumers, realtors, city planners, and others to use in their assessment of this trait. Alternative use in academic research has grown in recent years with more valid data supporting its methodology of determining the walkability of a location, but despite the merits as a consumer housing tool and in academic research it does contain limitations that should be addressed. My research findings indicate Walk Score data was not a significant variable in the regression analysis, meaning Walk Scores did not have any influence on home price. This section will review these limitations, and based on these findings, offer a suggestion for a walkability index that takes into account the limitations.

Walk Score was found in several research studies to not account for other walkability factors such as safety, environmental, or topographic deterrence (Gilderbloom, et al., 2015, Pivo and & Fisher, 2011, Carr, et al., 2010). Previous research also indicates that Walk Score can be useful to determine some walkable places, but cannot be universally applied to measure overall neighborhood walkability (Duncan, et al., 2011). Most important is that important factors relevant to actual walkability, such a road routes and environmental features such as lakes or parks that determine one's route to a destination, are not currently accounted for. Walk Score data is also absent street

quality; and the algorithm does not account for trees, places to sit, sidewalk width and overall aesthetic value of the walking route (Gildberbloom, et al., 2015, Leinberger & Alonzo, 2012, Pivo & Fisher, 2011).

Taken as a total Walk Score is not a perfect measure of walkability. The fact is it is a fluid data set, being updated as continued research identifies limitations. The website www.walkscore.com includes specific information on the methodology for determining scores and is updated as improvements are made to the algorithm. The data itself is changing as environments change. Walk Score is a useful starting point for some researchers, but there are other factors of walkability that should be measured when determining community walkability.

An Alternative Walkability Measure

I propose a different method of walkability that more broadly encompasses the health, social, and environmental benefits of a specific residential location. The current Walk Score value calculated for a location does little to capture the broader health and social aspects of walkability as an influence on home price. In Leinberger and Alfonso's (2012, p. 3) Washington D.C. study for the Brookings Institute, this lack of research was summarized as: "…The absence of a clear classification of the mix of residential, office, and retail elements that compromise walkable urban places or of the built environment components (including area, density, land use characteristics, transportation facilities, etc.) necessary to produce sustainable, economically viable, socially equitable places has been one of most significant barriers to addressing their demand. Metrics to gauge walkable urban places' performance that could guide investments decisions and public

policy development have also been absent". The Leinberger study initially used Walk

Score data for 201 neighborhoods and narrowed the data to include 66 places where there

were policies in place to promote walkability, mixed use development or higher densities.

This Leinberger study also focused solely on all places with Walk Scores greater than 90

which are considered a Walker's Paradise and only a representative sampling of the other

Walk Score levels indicating most of the location sample already had a high Walk Score,

again the scale is out of 100.

To develop metrics for measuring walkability I would propose not to eliminate

those places considered car dependent or less walkable as the Leinberger and Alfonso

study did. My metrics will include all possible types of environments and include them in

any place study to highlight what makes a location a "Walker's Paradise" and those

places not so much, so future investment can turn those places around so to speak. For

example, if the goal is to draw attention to places that capture the social, environmental,

and health aspects of walkability, a high walkability index as it is currently measured

may not be the best way to do this. There are other neighborhood features that promote

environment and health that are not in the current calculation of a Walk Score. Thus, a

different form of measure is needed.

The methodology I propose it to begin with the Walk Score (as currently

calculated) for a given location. The second step would be to conduct an audit of specific

neighborhoods whose boundaries are determined by similar Walk Scores, utilizing the

same method as the Leinberger and Alfonso (2012) study. In that study the researchers

used a 162 item Irvine Minnesota Inventory (IMI) "that collects objective data on built

environment characteristics hypothesized to be related to physical activity" (Leinberger & Alfonso, 2012, p. 6). The locations were additionally assessed for ten environmental characteristics believed to facilitate walking and which address the limitations of safety, aesthetic walking quality, and topographic characteristics:

11. Aesthetics (attractiveness, open views, outdoor dining, maintenance)

12. Connectivity (potential barriers such as wide thoroughfares)

13. Density (building concentrations and height)

14. Form (streetscape discontinuity)

15. Pedestrian amenities (curbcuts, sidewalks, street furniture)

16. Personal safety (graffiti, litter, windows with bars)

17. Physical activity facilities (recreational uses)

18. Proximity of uses (presence of non-residential land uses)

19. Public spaces and parks (playgrounds, plazas, playing fields)

20. Traffic measures (signals, traffic calming)

Therefore, my proposed methodology includes a base line walkability index with Walk Score data, a walkability assessment related to physical activity using the Irvine Minnesota Inventory, and an additional assessment of the environmental characteristics listed above, that theoretically promote walking. The final inventory is designed to capture the social aspects of communities. The Leinberger and Alfonso (2012) study additionally incorporated five indictors of social equity to include: income, diversity, education, affordability, and transportation accessibility. The researchers consider social equity metrics important to the overall walkability of a location as walkability is seen as a

way to increase a location's "triple bottom line: profit (economics), people (equity), and planet (environment)" Leinberger and Alfonso, 2012, p. 2). I would mirror these indicators as they are easily measurable and the data sources are consistent across metropolitan areas.

Taken together the four additional levels of indices provide a more inclusive measure of communities that address various aspects of what actually makes a community walkable, such as safety, community features that promote walking, and topographic features not currently accounted for Walk Score. Incorporating this level of assessment will help communities understand where they place in the walkability index, where to focus resources and how to achieve an overall greater walkable community. For instance, if one community has been identified as have higher education attainment, higher disposable income, and higher walkability we can almost guarantee the housing costs will inhibit racial diversity and social equality. City investment could target this hypothetical area to promote housing affordability by way of housing subsidies or other measures to create social diversity. Places with low walkability can implement policies to increase density, promote infill development, and increase public transportation or other measures to ensure future development focus on creating walkable places.

Policy Implications

The goal of this master's thesis was to better understand the importance of creating walkable communities and how to apply what was learned as policy actions that communities can implement to promote more sustainable, and hence, walkable communities. As indicated from this limited research endeavor, knowing the limitations

of Walk Score and accounting for the limitations and addressing them in a new walkability index can be half the battle in implementing or promoting measures for better designed communities. The policy implications from this are endless, from battling the unintended health consequences of a sedentary lifestyle to preserving valuable natural resources (think fossil fuel conservation, pollution and political unrest) to creating more diverse and equal societies.

Community change does not happen all at once and by the mere implementation of a policy by elected officials. It happens block by block, neighborhood by neighborhood. It takes knowledge of what is working in a community and a clear understanding of what needs to change. The ultimate intent of this research is for the information presented in this thesis to actually be a useful tool to promote community change with the goal of sustainable community design. One part of creating a sustainable community is knowing how walkable it is because walkability ties into so many other aspects of the health, social and environmental concerns of a community. Increased awareness and investment in walkable communities can promote change that benefits individuals, communities, and society as a whole.

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