Residential Land Values and Walkability

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Abstract We examine 5,603 property transactions in Jefferson County, Alabama that take place between 2004 and 2008. Using OLS regressions, we estimate the extent to which differences in walkability, as measured by Walk Score™, can explain the variability in land values. We find that after controlling for population growth and lot size, land values generally increase with walkability and that this result is stable over time. However, we find evidence that this impact reverses as neighborhoods become more car-dependent. This car dependency increases as the distance from the central business district increases. We consider the implications of our findings on mixed-use developments in what we believe is the first study to address walkability in this context of sustainable development.

Residential land values differ greatly by location. We consider the impact that walkability has on these differences. Walkability is a measure of how friendly a neighborhood is to walking to commonly demanded consumption amenities, such as work, schools, etc.[1] Walker-friendly neighborhoods have significant health, economic, and environmental benefits because, as noted by Lehman and Boyle (2007), it is easier for residents to get the daily exercise recommended by the Surgeon General and the Centers for Disease Control and Prevention (CDC) to combat obesity and a number of other health-related risk factors. Walkable neighborhoods are a housing intervention thought to have a positive impact on public health via minimizing carbon footprints. Also, neighborhoods where residents can walk to stores, schools, and jobs are thought to promote a healthier, pedestrian lifestyle. The environmental benefits from walkable neighborhoods derive from a decrease in motor vehicle usage, which in turn cuts down on harmful emissions polluting the air. This decrease in motor vehicle traffic can also provide an economic benefit to residents because the disposable income ordinarily allocated toward auto expenses can be used for other necessities. Neighborhoods, such as mixed-use developments, that offer these various health, convenience, and environmental benefits are considered to be more sustainable over time.

The aim of this paper is to determine to what extent the benefits of walkable neighborhoods are reflected in land values. We focus on land values as opposed to overall home values in order to remove some of the non-location 'noise' in our analyses. That is, we wish to determine the degree to which specific location-related elements impact value as opposed to improvements. In order to isolate that effect, we attempt to ignore, as much as possible, valuation factors that could be easily replicated at another location. A home, for example, could be constructed in the same manner in virtually any location in the country meeting space and zoning requirements. Neighborhood amenities, services, and other location-related value factors may not be easily transported and are the focus of our study. Miller (1982) organized the determinants of residential property value into five broad categories: physical attributes, location, financial factors, transaction costs, and inflation relative to market price. This paper focuses on the location-based factors, particularly given the walkability characteristics of that location. Of Miller's three location-based subcategories (fiscal, transportation costs, and economic externalities), walkability fits in the category of economic externalities. The author included issues such as air quality, race, public facilities, noise, and public housing that affect the quality of life within a neighborhood. Walkability is akin to public facility access, but (to our knowledge) has not yet been studied in the context of residential land values.

We hypothesize that walkability matters. We expect that land values are higher in neighborhoods that are easily accessible to services and that this impact may be muddied in certain areas when overall home values are studied as opposed to the land itself. This is because in lower income neighborhoods, the structures in place are smaller with fewer bedrooms and bathrooms and are therefore less valuable than the structures that are typical of higher income neighborhoods.

The paper is organized as follows. Section two provides a review of the existing literature in the area of property valuation with an emphasis on land values versus home values. Section three describes the data and methodology. Section four presents the results. And section five provides conclusions and policy implications.

Review of the Literature

Studies of land values have focused on the specific factors in the built environment that impact land values. Exhibit 1 summarizes much of what has been reported regarding these factors. Certain characteristics, when present in a neighborhood, have been found to enhance property values while others have been found to be value-reducing. With regard to population change, initially it was not clear if there was a correlation between realized or forecasted growth and land values. Mertzke (1926) studied 37 Wisconsin cities with a population of 5,000 or more and determined that there was little correlation between land values and changes in population. However, later studies by Capozza and Helsley (1989) and Guntermann (1997) confirmed that the price of land in rapidly growing cities reflects a premium based on future growth expectations. Thus, a forward-looking versus backward-looking approach to population change is key in valuation. With changes in population, access to public transportation becomes important as well, especially as one considers locations farther from the central city. Hayes (1957), Benson, Hansen, Schwartz, and Smersh (1998), and Bond, Bond, Seiler, and Seiler (2002) and more recently Giuliano, Gordon, Pan, and Park (2010) studied the value related to water features. Giuliano et al., however, found that lot size, home size, and proximity to the coast were more important than accessibility. Besides general accessibility, proximity to amenities and favorable topography have also been shown to increase land values. Several papers such as Do and Grudnitski

Exhibit 1 | Empirical Evidence of the Impact of Location Features on Land Values

Location Features	Value Adding	Value Destroying	Indeterminate
Population Change	Capozza and Helsley (1989); Guntermann (1997)		Mertzke (1926)
Rail Stations	Hayes (1957)		
Water-Based Features	Hayes (1957); Benson, Hansen, Schwartz, and Smersh (1998); Bond, Seiler, and Seiler (2002); Giuliano, Gordon, Pan, and Park (2010)		
Proximity to Urban Areas, Malls and Roads	Hayes (1957); Kaltsas, Bosch, and McGuirk (2008)		
Proximity to Industrial Areas		Hayes (1957); Asabere and Huffman (1991); McMillen and McDonald (2002)	
The Torrens System	Miceli, Munneke, Sirmans, and Turnbull (2002)		
Parcel Size		Kaltsas, Bosch and McGuirk (2008)	
Golf Courses	Do and Grudnitski (1995)		

Note: This table presents the findings of existing literature in the area of land valuation.

(1995), Benson, Hansen, Schwartz, and Smersh (1998), and Bond, Seiler, and Seiler (2002) have examined the impact of amenities on residential property values. These studies, however, study the value that a specific amenity such as water views or golf course access adds. Pivo and Fisher (2011) also consider neighborhood amenities and use Walk Score™, which takes into consideration all amenities within one mile of a given property.

Walk Score scores locations on a 100-point scale with respect to the ease with which one could live without a car. Thus, locations scoring 90 points or better are dubbed a ''Walker's Paradise'' while locations scoring under 25 points are labeled as ''Car-Dependent.'' The scoring algorithm awards the most points for amenities within 0.25 miles of the given location based on data from Google (for mapping), Education.com (for school listings), Open Street Map (for additional mapping resources), and Localeze (for business listings). There are some limitations of Walk Score in that while it attempts to approximate walkability, not all factors are included in its algorithm, such as street design, safety, topography, and weather. That is, the Walk Score is strictly based on the distance between a location and all amenities within a one-mile radius. Also, the distances used are ''as the crow flies'' distances as opposed to the actual distance walked along street grids. In effect, Walk Score assumes that residents can walk to each amenity using a straight path. In addition, Walk Score does not consider proximity to public transit. A new metric, Transit Score, does account for access to public transportation, but Birmingham is not currently one of the cities where Transit Scores are available.[2]

However, while a ''Street Smart'' Walk Score is in production that will consider intersection density, block length, and other walking issues, Carr, Dunsiger, and Marcus (2010) test the validity and reliability of Walk Score for estimating access to objectively measured walkable amenities. They find significant correlations between Walk Score and all categories of aggregated walkable destinations within a one-mile buffer of their sample addresses and conclude that Walk Score is a reliable and valid measure of estimating access to walkable amenities.

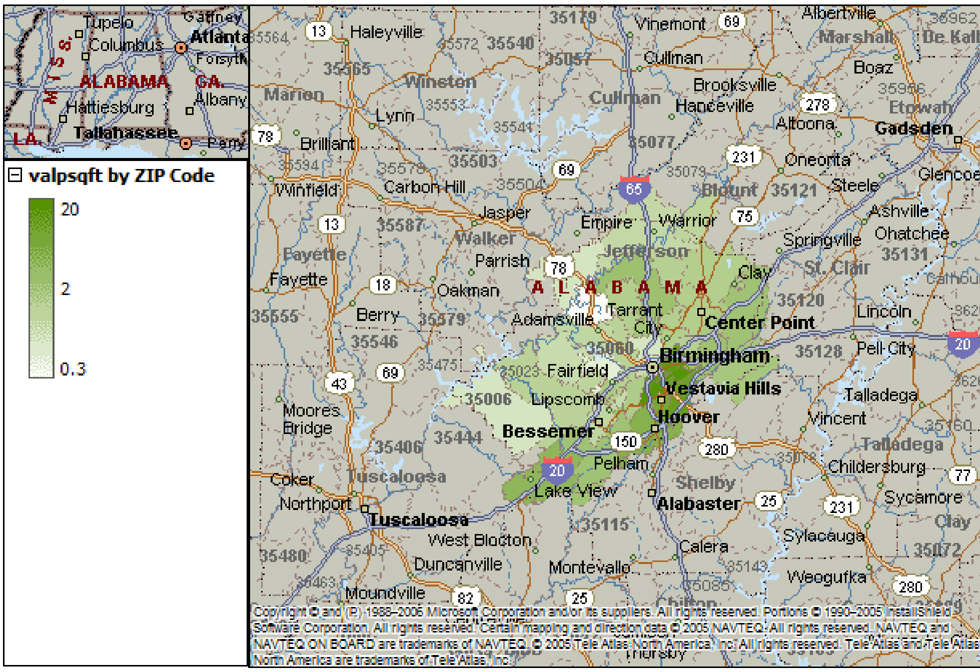
Pivo and Fisher (2011) find that proximity to amenities, hence, walkability increases value, but their focus is on commercial real estate values. Cortright (2009) studies 15 metro areas including Chicago, San Francisco, Sacramento, Austin, and Charlotte where the value of Walk Score was greatest and uses Walk Score to determine its impact on house values. The author finds that homes that rank as above-average in walkability command premiums of $4,000 to $34,000 over homes in less walkable neighborhoods.

Several other studies have used Walk Score data in various ways. For example, Rauterkus, Thrall, and Hangen (2010) use Walk Score data to show that walkability is associated with a lower mortgage default probability. They argue that walkable neighborhoods allow residents to spend less on vehicle-related expenses, thereby making their housing costs more affordable. Rogers, Halstead, Gardner, and Carlson (2011) use a case study set in New Hampshire to argue that walkable neighborhoods improve quality of life by generating and maintaining social capital. That is, their survey of New Hampshire residents indicates that respondents living in more walkable neighborhoods reported higher social capital as well as a better quality of life than those in less walkable neighborhoods.

Hayes (1957) found that land values decrease with proximity to industrial areas. Asabere and Huffman (1991) found that this decrease in value is 58% when considering lots that were actually zoned for industrial use versus those that were not. McMillen and McDonald (2002) found support for this finding with their own result that residential zoning led to higher land value growth rates than commercial zoning after a new zoning ordinance in Chicago in 1923. In some areas, however, parcel value per unit declines with increasing parcel size (Kaltsas, Bosch, and McGuirk, 2008).

Our study focuses on residential versus commercial land values. Because we ignore structure values by focusing only on land values, we are left to consider factors unique to the neighborhood that may have an impact on land values. Prior literature has suggested that these locational issues include forecasted population change, access to public transit, water-based features, proximity to urban and industrial areas, parcel size, and amenities. Our primary focus is on the value added by neighborhood amenities and we measure the proximity to amenities by using Walk Score. We then move the discussion of amenity value to a broader

Exhibit 2 | Mean Land Value per Square Foot by ZIP Code in Jefferson County, AL



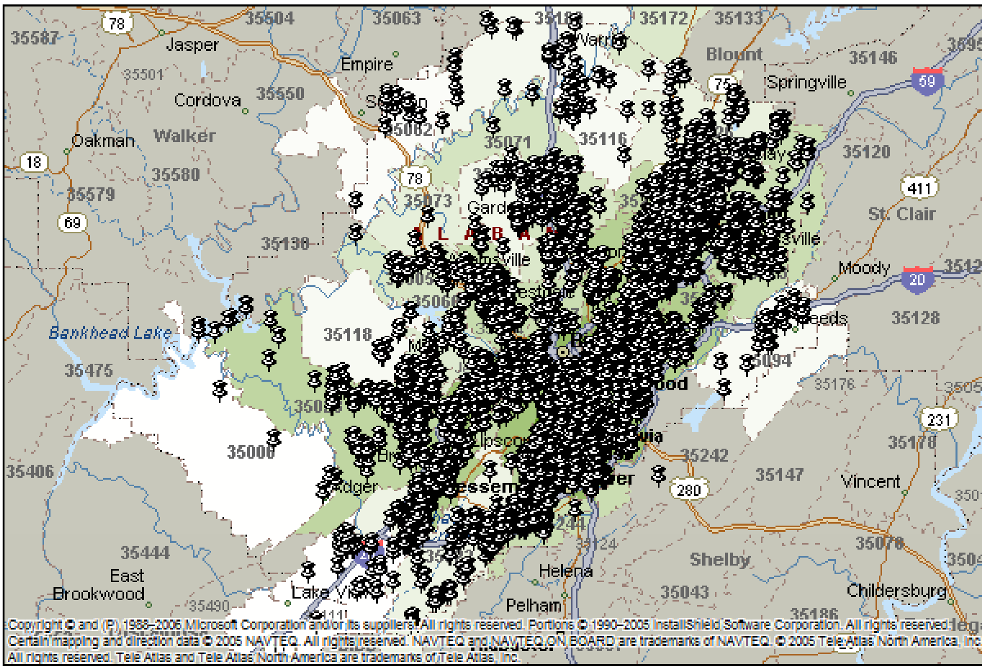
discussion of sustainability. That is, does walkability add value? We control for factors known to impact land values by including these factors in our robustness tests.

Data and Methodology

Our study location is Jefferson County Alabama, which includes the Birmingham-Hoover Metropolitan Statistical Area (MSA). Jefferson County had a population of 658,466 in 2010 according to the U.S. Census Bureau and is the most populated county in Alabama. We obtained data from the Jefferson County Tax Commissioner on all property sales in the county from January 2004 to December 2008.[3] This data includes information related to the property sale, as well as characteristics of the property, such as lot size and land value, along with characteristics of the existing structure.[4] Our key variables of interest are land value and Walk Score as we are attempting to estimate the degree to which walkability, as measured by Walk Score, explains variation in land values. In order to isolate the explanatory power of walkability, we control for other factors known to affect land values, such as lot size and population growth.

Exhibit 2 is a heat map of the study data depicting the variability in land values per square foot across ZIP Codes. This map shows that land values are the highest in the neighborhoods of Mountain Brook, Avondale, and Vestavia Hills, near the

Exhibit 3 | Mean Walk Score by ZIP Code in Jefferson County, AL



airport and near two universities. These three neighborhoods have the highest median income levels in the county. Mountain Brook and Avondale are two of the oldest communities in the county, with many homes listed on the historical register.

For each property, we obtain its Walk Score. As noted previously, higher scores are indicative of more walkable locations and therefore should generally correlate with more walkable neighborhoods, whereas locations with scores below 50 are considered to be car-dependent. After mapping the property addresses to obtain geographic coordinates for each location, we apply the Walk Score algorithm to obtain the Walk Score for each location. Again, the Walk Score algorithm awards points based on the distance to the closest amenity in each category and no points are awarded for amenities located more than one mile from the subject address.[5]

Given the nature of the Walk Score methodology, we had concerns about whether it measured only proximity to amenities and not true walkability. We argue that population density would be an appropriate proxy for proximity. Throughout our analysis, we substituted population density for Walk Score. While we found similar results at times, the findings were not identical, which indicates that Walk Score measures something other than strictly population density.[6]

Exhibit 3 is a map of the study data depicting the variability in Walk Scores across ZIP Codes, along with sales transactions for the sample period of 2004 to 2008. Each pushpin on the map represents a sale, while the background color on the

Exhibit 4 | Descriptive Statistics: Entire Sample

	Mean	Median	Min.	Max.	Std. Dev.
Total Land Value ($)	60,192	35,700	2,200	1,318,300	69,390
Total Land Area (ft.^{2})	19,774	14,962	1,400	1,812,912	41,121
Land Value per Square Foot ($)	4.94	2.48	0.04	62.18	6.43
Population Growth (%)	0.61	0.00	−3.20	7.00	1.53
Walk Score	26.94	23.00	0.00	94.00	20.32
Land Leverage (%)	30.65	32.00	0.00	177.14	17.52
Sale Price ($)	179,872	150,000	20,000	1,750,000	119,878

Notes: This table summarizes the sample of data used in the study. We examine 5,603 properties in Jefferson County, Alabama that were sold between 2004 and 2008.

map is darkest in areas where the Walk Score is highest and the background color is lightest in areas where the Walk Score is lowest. Walk Scores are generally low with the highest values near the universities and in the neighborhood of Homewood, which is one of the most walkable neighborhoods in all of Alabama. In addition, the map appears to indicate that sales transactions are more prevalent in the more walkable neighborhoods as opposed to the less dense areas to the north and east.

Exhibit 4 provides the descriptive statistics for the sample. Our sample includes 5,603 properties. The average (median) land value is $60,192.61 ($35,700). These land values are reported separately from total sales price by the county tax assessor. The median land value is in line with average land value data from the Lincoln Institute. The Lincoln Institute reports that from 2004 to 2008 (our sample period), the average land value in Alabama was $44,314. The average (median) lot size in our sample is 19,774.65 (14,962.89) square feet. This equates to average lot sizes of just under half an acre. The ratio of land values to lot sizes results in average (median) land values per square foot of $4.94 ($2.48). We use population growth from 2000 to 2009 at the Census tract level (estimated by ESRI) as a proxy for future growth. This measure was found by Capozza and Helsley (1989) and Guntermann (1997) to be positively related to land value increases. Overall, population growth across our sample neighborhoods was minimal, as indicated by a median value of 0.00.

We use the exact locations of the properties in our sample to obtain Walk Score by creating a batch file containing the longitude and latitude coordinates for every property. We then upload this file to the Walk Score file server and use ColdFusion programming to request and download the corresponding Walk Scores. The average (median) Walk Score for the properties in our sample is 26.94 (23.00), indicating that the average property is located in a car-dependent neighborhood due to the fact that only a few amenities are within walking distance. According to Walk Score, the 53 largest cities in Alabama have an average Walk Score of

Exhibit 5 | Walk Score Frequency

Walk Score Range	Category Description	Frequency
90–100	Walker's Paradise (Hoboken, NJ)	2
70–89	Very Walkable (New York, NY)	183
50–69	Somewhat Walkable (Los Angeles, CA)	620
25–49	Somewhat Car Dependent (Phoenix, AZ)	1,954
0–24	Car Dependent (Port St. Lucie, FL)	2,844
	Total	5,603

Notes: This table reports the frequency of Walk Scores in the sample data within specific bands. In the Category Description column, examples are given (in parentheses) of cities outside of Alabama where the average Walk Score places it in the given category.

31, while one of the most walkable cities, Homewood, Alabama, lies within our sample area and has a Walk Score of 55. We edited the Walk Score values by adding 0.5 to all observations before taking log transformations. This eliminated the problem of taking log transformations of observations with zero values. Further, adding this constant uniformly across all observations does not alter the statistical significance of the results.

In order to gain a better understanding of the frequency distribution of Walk Scores across the various categories of walkability as defined by Walk Score, we created dummy variables corresponding to each category. This distribution is reported in Exhibit 5.

The average (median) sale price of the properties in our sample is $179,872.50 ($150,000.00). We use this value along with land values to compute land leverage, as in Bostic, Longhofer, and Redfearn (2007). Bostic et al. proposed that houses with a greater amount of land leverage—the ratio of a property's land value to total property value—will have relatively more volatile prices. This hypothesis is based on the argument that when unbundling property values into the components of land and structure values, land value is the ultimate source of house price appreciation and thus the main driver of property values and volatility. Their empirical analysis using data from Wichita, Kansas showed evidence of a positive relation between house price volatility and land leverage. In our sample, average (median) land leverage is 30.65% (25.31%).

Exhibit 6 describes the correlations between our key variables. While our dependent variable in our primary regression analysis is *lnvalpsqft* and *lnLandLeverage* in our robustness checks, our concern here is the extent to which our independent variables (*lnWalkScore*, *PopGrowth*, and *lnLotSize*) are correlated.

We hypothesize that the more walkable a neighborhood, the greater the land values in that neighborhood. This walkability accounts for neighborhood amenities and speaks to the value of neighborhood design and sustainability. As an anchor for

Exhibit 6 | Correlation Matrix

	lnvalpsqft	*lnWalkScore*	*PopGrowth*	*lnLotSize*	*lnLandLeverage*
lnvalpsqft	1				
lnWalkScore	0.3271	1			
	(0.0000)				
PopGrowth	−0.0120	−0.3843	1		
	(0.3697)	(0.0000)			
lnLotSize	−0.5785	−0.2390	−0.0933	1	
	(0.0000)	(0.0000)	(0.0000)		
lnLandLeverage	0.5949	0.3328	−0.1598	0.0749	1
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	

Notes: This table presents the correlation coefficients for the key variables with *p*-values shown in parentheses. There are 5,603 observations. *lnvalpsqft* is the natural logarithm of the land value per square foot of the property. *lnWalkScore* is the natural log of the property's Walk Score. *PopGrowth* is the population growth percentage since the 2000 Census. *lnLotSize* is the natural logarithm of the size of the parcel. *lnLandLeverage* is the natural logarithm of the ratio of the land value to the sale price.

our discussion, we use the Girardet (1999) definition of a sustainable city. He defines a sustainable city as one that is "organized so as to enable all its citizens to meet their own needs and to enhance their well-being without damaging the natural world or endangering the living conditions of other people, now or in the future." We argue that walkability allows for sustainability because easy access to amenities makes it easier for citizens to meet their own needs. We estimate the impact of walkability on land values using an OLS regression of the following form:

$$\text{Residential land value} = f(\text{walkability, population change, parcel size) and alternatively} \quad (1)$$

$$\text{Land Leverage} = f(\text{walkability, population change, parcel size).} \quad (2)$$

We anticipate that land value will increase with walkability and population change and decrease with parcel size. We expect these results to hold across our alternative specification using land leverage as the dependent variable.

For robustness, we divide our sample based on Walk Score. We divide the sample into two halves: observations above and below the median value. Exhibit 7 summarizes the subsamples relative to Walk Score. Total land value and land value per square foot are lower for properties whose Walk Score is at or below the median. Land area, population growth, and travel time to work are greater for

Exhibit 7 | Descriptive Statistics: Walk Score Subsamples

	Mean	Median	Min.	Max.	Std. Dev.
Panel A: Observations at or Below the Mean Walk Score (*N* = 2,844)					
Total Land Value ($)	47,954.22	34,300.00	2,200.00	968,000.00	53,414.72
Total Land Area (ft.^{2})	24,590.07	16,015.31	1,610.22	1,812,912.00	55,735.39
Land Value per Square Foot ($)	3.36	2.11	0.04	54.14	4.24
Population Growth (%)	1.17	0.70	−3.20	7.00	1.72
Walk Score	10.49	11	0	23	7.76
Travel Time (minutes)	26.77	27.20	15.70	43.80	4.33
Panel B: Observations Above the Median Walk Score (*N* = 2,759)					
Total Land Value ($)	72,808.05	39,000.00	3,400.00	1,318,300.00	80,780.26
Total Land Area (ft.^{2})	14,810.88	12,664.02	1,400.09	213,865.10	13,560.15
Land Value per Square Foot ($)	6.57	3.39	0.15	62.18	7.75
Population Growth (%)	0.03	−0.10	−3.10	7.00	1.01
Walk Score	43.89	42	25	94	14.49
Travel Time (minutes)	22.74	22.50	10.40	41.80	4.72
Panel C: Difference in Samples (Panel A–Panel B)					
Total Land Value ($)	−24,853.80***	−4,700.00	−1,200.00	−350,300.00	−27,365.50
Total Land Area (ft.^{2})	9,779.19***	3,351.30	210.12	1,599,046	42,175.24
Land Value per Square Foot ($)	−3.20***	−1.29	−0.11	−8.04	−3.51
Population Growth (%)	1.14***	0.80	−0.10	0.00	0.72
Walk Score	−33.39***	−31.00	−25.00	−71.00	−6.73
Travel Time (minutes)	4.03***	4.70	5.30	2.00	−0.39

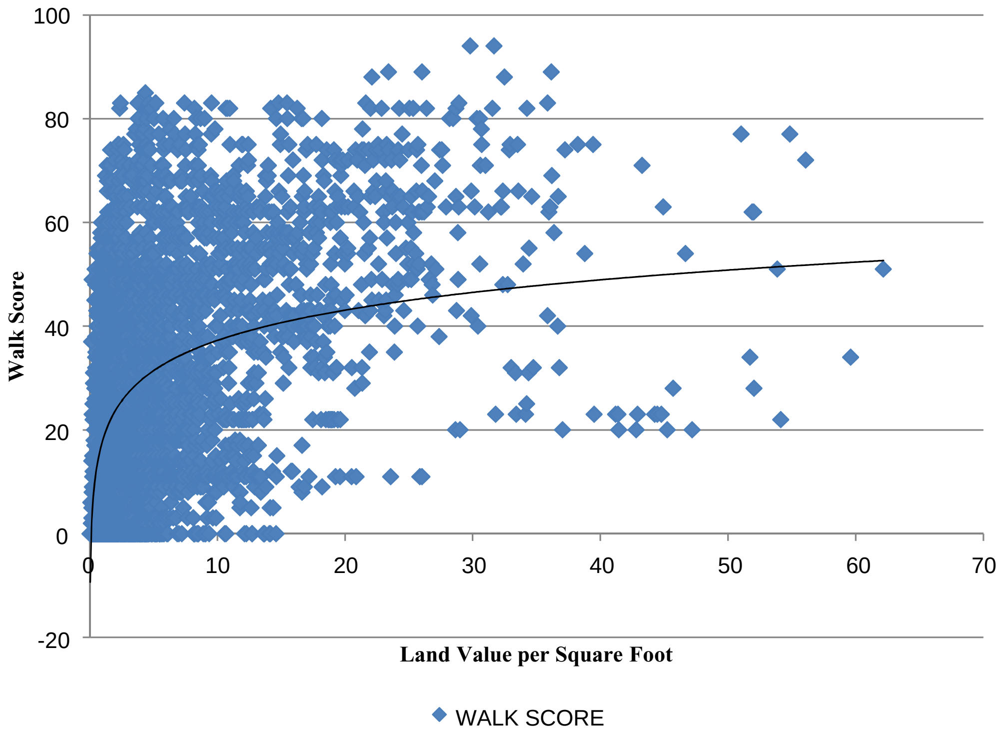
Notes: This table summarizes the sample of data used in the study. We examine 5,603 properties in Jefferson County, Alabama that were sold between 2004 and 2008 and divide the sample based on the median Walk Score in the full sample. All observations with a Walk Score at or below 23 are placed in one subsample. All observations with a Walk Score above this value are placed in a separate subsample.
*The difference between the mean values across the two samples is significant at the 10% level.
**The difference between the mean values across the two samples is significant at the 5% level.
***The difference between the mean values across the two samples is significant at the 1% level.

properties whose Walk Score is above the median. These differences are all highly significant.

Results

Exhibit 8 plots the data in our full sample. The data appear to follow a log-linear pattern consistent with other walkability studies such as Cortright (2009) and Pivo and Fisher (2011).

Exhibit 8 | Walk Score vs. Land Values



We estimate OLS regressions in order to determine the linkage between land values and Walk Score. The results of our regression analysis are presented in Exhibit 7. All of our explanatory variables are significant. Both Walk Score and population growth increase with land values while lot sizes decrease with land values. This result indicates that walkability does enhance land values. The results from our control variables (population growth and lot sizes), consistent with Capozza and Helsley (1989) and Guntermann (1997), show that population growth does tend to be value increasing as an influx of residents to an area drives up property demand and therefore prices. Lot sizes in our sample decline as land values increase, consistent with Colwell (1990) and Kaltsas, Bosch, and McGuirk (2008). This may be because developers attempt to maximize cash flows by carving valuable land into smaller lots, thereby increasing population density. Buyers must then travel further away from the central business district to purchase larger lots. These lots, in turn, may be less valuable with regard to price per square foot of land. These results are consistent across our subsamples. However, the significance differs somewhat, as evidenced by the *t*-statistics. To gain a better understanding of the impact of Walk Scores on land values in walkable neighborhoods versus car-dependent neighborhoods, we re-estimated these models using the full sample and dummy variables indicating which Walk Score range each property falls in according to the categories discussed and listed previously in Exhibit 5. The results of this analysis are shown in Exhibit 9. All of the dummy

Exhibit 9 | Land Value Regression Results

	Model 1	Model 2	Model 3
Panel A: Full Sample			
Intercept	0.4387 (15.88***)	9.3051 (45.65***)	16.2998 (88.23***)
lnWalkScore	0.2310 (25.91***)	0.0381 (4.30***)	0.0394 (5.42***)
lnTravelTime		−2.6126 (−43.80***)	−2.7871 (−62.49***)
lnLotSize			−0.6505 (−55.63***)
PopGrowth			0.1287 (20.96***)
lnStructAge			−0.1029 (−13.76***)
F-statistic	671.28***	1,409.55***	1,995.86***
Adj. R^2	0.1070	0.3346	0.6428
N	5,603	5,603	5,544
Panel B: Low Walk Score Subsample (Walk Score Less than 24)			
Intercept	0.5700 (21.34***)	6.1885 (17.73***)	14.3428 (55.62***)
lnWalkScore	0.1328 (11.37***)	0.0510 (4.16***)	0.0403 (4.94***)
lnTravelTime		−1.6707 (−16.14***)	−2.0123 (−30.01***)
lnLotSize			−0.7069 (−51.98***)
PopGrowth			0.0960 (15.03***)
lnStructAge			−0.1049 (−13.18***)
F-statistic	129.29***	200.78***	1,056.78***
Adj. R^2	0.0435	0.1232	0.6532
N	2,844	2,844	2,804
Panel C: High Walk Score Subsample (Walk Score Greater than 23)			
Intercept	−3.2975 (−15.59***)	8.6499 (24.65***)	15.0670 (41.97***)
lnWalkScore	1.2424 (22.06***)	0.4429 (8.91***)	0.3502 (8.22***)
lnTravelTime		−2.8868 (−38.92***)	−3.0315 (−48.47***)
lnLotSize			−0.5577 (−27.83***)
PopGrowth			0.1706 (12.87***)
lnStructAge			−0.1133 (−7.88***)
F-statistic	486.71***	1,134.45***	885.66***
Adj. R^2	0.1500	0.4511	0.6176
N	2,759	2,759	2,740

Notes: This table presents the results of OLS regressions to explain the variability of land values across properties in Jefferson County, Alabama. *t*-statistics are shown in parentheses. The dependent variable in each model is *lnvalpsqft* which is the log transformation of the land value per square foot.
*The difference between the mean values across the two samples is significant at the 10% level.
**The difference between the mean values across the two samples is significant at the 5% level.
***The difference between the mean values across the two samples is significant at the 1% level.

Exhibit 10 | Land Value Alternative Subsample Results

	Model 1	Model 2	Model 3
Intercept	2.7935 (4.41***)	10.0995 (16.97***)	17.0015 (38.11***)
lnWalkScore	0.1390 (11.60***)	0.0198 (1.78*)	0.0248 (2.91***)
lnTravelTime		−2.3852 (−38.27***)	−2.6137 (−56.29***)
lnLotSize			−0.6394 (−55.00***)
PopGrowth			0.1257 (20.59***)
lnStructAge			−0.1074 (−14.49***)
VeryWalkable	−1.0570 (−1.67*)	−0.9354 (−1.66*)	−0.8684 (−2.11**)
SomewhatWalkable	−1.5050 (−2.38**)	−1.2155 (−2.16**)	−1.1257 ((−2.75***)
SomewhatCarDependent	−2.1931 (−3.47***)	−1.5347 (−2.73***)	−1.3467 (−3.29***)
CarDependent	−2.2346 (−3.54***)	−1.5147 (−2.69***)	−1.3449 (−3.28***)
F-statistic	247.64***	504.38***	1,155.18***
Adj. R^2	0.1804	0.3503	0.6521
N	5,603	5,603	5,544

Notes: This table reports the results of an alternative method for creating subsamples of the dataset based on Walk Score. Dummy variables (*Paradise, VeryWalkable, SomewhatWalkable, SomewhatCarDependent,* and *CarDependent*) are created in conjunction with the five categories of Walk Scores and included in the models. The dependent variable in all models is *lnvalpsqft*.
*The difference between the mean values across the two samples is significant at the 10% level.
**The difference between the mean values across the two samples is significant at the 5% level.
***The difference between the mean values across the two samples is significant at the 1% level.

variables in these alternative specifications are negative and statistically significant. In addition, the significance of these variables increases with lower Walk Scores. This result suggests that in areas that are the most car dependent, Walk Score has the greatest impact on land values (Exhibit 10).

For robustness, we estimate our models using an alternative dependent variable. The results of this analysis are presented in Exhibit 11. Here, we substitute land value per square foot with land leverage, which is the ratio of land value to sale price. While we continue to see a positive, significant relation with Walk Score, population growth, one of our control variables, loses significance in our high Walk Score subsample. This result suggests that the degree to which total property values are driven by land values is not related to population growth in highly walkable neighborhoods. This may be because the highly walkable neighborhoods tend to be older, developed neighborhoods closer to the CBD and population growth tends to cause more development in the outer areas of a city, as has been the case in Birmingham, Alabama. In addition, the adjusted R-squared values are lower for the low Walk Score sample than the high Walk Score sample and the full sample. This may be because when examining only a sample of properties

Exhibit 11 | Land Leverage Regression Results

	Model 1	Model 2	Model 3
Panel A: Full Sample			
Intercept	−1.6468 (−115.91***)	2.4558 (22.70***)	1.4559 (11.35***)
lnWalkScore	0.1193 (26.03***)	0.0301 (6.39***)	0.0286 (5.68***)
lnTravelTime		−1.2089 (−38.18***)	−1.2393 (−40.03***)
lnLotSize			0.0898 (11.06***)
PopGrowth			0.0418 (9.81***)
lnStructAge			0.0716 (13.79***)
F-statistic	677.35	1,155.69***	596.05***
Adj. R^2	0.1079	0.2919	0.3493
N	5,603	5,603	5,544
Panel B: Low Walk Score Subsample (Walk Score Less than 24)			
Intercept	−1.5869 (−123.52***)	0.7986 (4.71***)	0.2685 (1.41)
lnWalkScore	0.0713 (12.70***)	0.0366 (6.14***)	0.0238 (3.95***)
lnTravelTime		−0.7093 (−14.11***)	−0.7368 (−14.88***)
lnLotSize			0.0446 (4.44***)
PopGrowth			0.0256 (5.42***)
lnStructAge			0.0696 (11.84***)
F-statistic	161.20***	185.73***	123.94***
Adj. R^2	0.0537	0.1150	0.1799
N	2,844	2,844	2,804
Panel C: High Walk Score Subsample (Walk Score Greater than 23)			
Intercept	−3.1513 (−26.95***)	2.6405 (12.82***)	0.6406 (2.68***)
lnWalkScore	0.5289 (16.99***)	0.1413 (4.85***)	0.1914 (6.75***)
lnTravelTime		−1.3994 (−32.14***)	−1.4032 (−33.74***)
lnLotSize			0.1703 (12.78***)
PopGrowth			0.0547 (6.69***)
lnStructAge			0.0639 (6.69***)
F-statistic	288.52***	714.88***	381.52***
Adj. R^2	0.0947	0.3411	0.4099
N	2,759	2,759	2,740

Notes: This table presents the results of OLS regressions to explain the variability of land values across properties in Jefferson County, Alabama. *t*-statistics are shown in parentheses. The dependent variable in each model is *lnLandLeverage*, which is the log transformation of the ratio of land value to sale price.
*The difference between the mean values across the two samples is significant at the 10% level.
**The difference between the mean values across the two samples is significant at the 5% level.
***The difference between the mean values across the two samples is significant at the 1% level.

Exhibit 12 | Land Leverage Alternative Subsample Results

	Model 1	Model 2	Model 3
Intercept	−0.3959 (−1.20)	3.0076 (9.48***)	1.9379 (6.24***)
lnWalkScore	0.0727 (11.67***)	0.0172 (2.90***)	0.0129 (2.18**)
lnTravelTime		−1.1112 (−33.45***)	−1.1369 (−35.15***)
lnLotSize			0.0979 (12.09***)
PopGrowth			0.0412 (9.69***)
lnStructAge			0.0683 (13.24***)
VeryWalkable	−0.6248 (−1.90*)	−0.5682 (−1.89*)	−0.5737 (−2.00**)
SomewhatWalkable	−0.8623 (−2.63***)	−0.7275 (−2.43**)	−0.7132 (−2.50**)
SomewhatCarDependent	−1.1477 (−3.50***)	−0.8410 (−2.81***)	−0.8368 (−2.94***)
CarDependent	−1.1934 (−3.63***)	−0.8580 (−2.86***)	−0.8724 (−3.06***)
F-statistic	220.45***	406.95***	349.61***
R^2	0.1638	0.3030	0.3614
N	5,603	5,603	5,544

Notes: This table reports the results of an alternative method for creating subsamples of the dataset based on Walk Score. Dummy variables (*Paradise, VeryWalkable, SomewhatWalkable, SomewhatCarDependent*, and *CarDependent*) are created in conjunction with the five categories of Walk Scores and included in the models. The dependent variable in all models is *lnLandLeverage*.
*The difference between the mean values across the two samples is significant at the 10% level.
**The difference between the mean values across the two samples is significant at the 5% level.
***The difference between the mean values across the two samples is significant at the 1% level.

located in car-dependent neighborhoods, factors such as school quality drive land values that are not incorporated in our models.

We estimate the same alternative models as in the land value specifications. The results of that analysis are presented in Exhibit 12. Similarly, we find evidence of a stronger significance in more car-dependent areas. That is, Exhibit 11 indicated that in strictly car-dependent areas, other factors besides walkability, travel time to work, lot size, population growth, and structural age influence land values. These results indicate that when comparing areas of varying levels of walkability, land values decline as car dependency strengthens.

To further examine differences between walkable neighborhoods and car-dependent neighborhoods, we estimate our regression model on a subsample of data from a walkable neighborhood and on a subsample of data from a car-dependent neighborhood. ZIP Code 35071 covers Gardendale, Alabama. This neighborhood has a very low population density at 264 people per square mile as of 2010 according to the U.S. Census. ZIP Code 35209 covers Homewood, Alabama, which is much more densely populated at 2,921 people per square mile as of 2010 according to the U.S. Census. Homewood is also one of the most walkable neighborhoods in Alabama.

Exhibit 13 | ZIP Code Regression Results

	ZIP Code 35071	ZIP Code 35209
Panel A: Dependent Variable is *lnvalpsqft*		
Intercept	9.5311 (16.24***)	4.5892 (5.43***)
lnWalkScore	0.1533 (1.38)	0.5574 (4.08***)
PopGrowth	0.2118 (3.58***)	−0.0930 (−2.71***)
LnLotSize	−0.9544 (−29.25***)	−0.4458 (−6.30***)
F-statistic	329.05***	25.90***
R^2	0.9481	0.2691
N	58	215
Panel B: Dependent Variable is *lnLandLeverage*		
Intercept	−2.0841 (−3.12***)	−4.3020 (−7.77***)
lnWalkScore	0.3722 (2.94***)	0.1869 (2.09**)
PopGrowth	0.1249 (1.85*)	−0.0678 (−3.02***)
LnLotSize	−0.0638 (−1.72*)	0.3298 (7.12***)
F-statistic	6.97***	19.18***
R^2	0.2792	0.2143
N	58	215

Notes: This table presents the results of OLS regressions to explain the variability of land values across properties in specific ZIP Codes in Jefferson County, Alabama. In ZIP Code 35071, the mean Walk Score is 16.44; in ZIP Code 35209, the mean Walk Score is 59.64. *t*-statistics are shown in parentheses.
*The difference between the mean values across the two samples is significant at the 10% level.
**The difference between the mean values across the two samples is significant at the 5% level.
***The difference between the mean values across the two samples is significant at the 1% level.

We find that in Gardendale, walkability does not explain the variability in land values while walkability is positive and significant in our Homewood regression. Also, we find that population growth increases with land values and land leverage in walkable neighborhoods but decreases with land values and land leverage in walkable neighborhoods. We argue that this result is because changes in land value due to population growth tend not to affect walkable neighborhoods. This is because when there is a significant increase in population, new residents tend to gravitate toward outlying areas where more land and housing is available than the walkable communities near the CBD.

In our land leverage models, we find that lot size decreases but loses some of its explanatory power when walkability is low and *increases* with land leverage when walkability is high. We argue that this result is because lot sizes tend to be much smaller in walkable neighborhoods near the CBD where land is limited. Here, larger lots sell at a premium. These ZIP Code-level findings are somewhat

Exhibit 14 | Two Stage Regression Results

	Dependent Variable = *lnsalesprice*	Dependent Variable = *Residuals*	Dependent Variable = *lnsalesprice*
Intercept	10.4670 (121.83***)	−0.2035 (−14.44***)	9.7868 (108.51***)
lnStructAge	−0.1261 (−22.11***)		−0.1688 (−28.41***)
lnSqFt	0.1925 (21.00***)		0.2458 (26.48***)
PopChange	0.0310 (6.37***)		0.0480 (10.01***)
lnWalkScore		0.0733 (16.14***)	0.1043 (19.44***)
F-statistic	409.85***	260.64***	422.82***
R^2	0.1816	0.0449	0.2339
N	5,544	5,544	5,544

Notes: This table presents the results of OLS regressions to explain the variability of housing prices in Jefferson County, Alabama. *t*-statistics are shown in parentheses.
*The difference between the mean values across the two samples is significant at the 10% level.
**The difference between the mean values across the two samples is significant at the 5% level.
***The difference between the mean values across the two samples is significant at the 1% level.

inconsistent with our initial results from the full sample and suggest that while walkability matters, the extent to which it has an impact on land value differs in walkable communities versus car-dependent ones (Exhibit 13).

Due to the possibility of biases in the assessor valuations of land values, we consider the impact of walkability using (full) sales prices that include structures and land. We estimate a two-stage regression where the first regression takes the following form:

$$\text{Sales price} = f(\text{age, square footage, population change}) + \varepsilon. \quad (3)$$

We hypothesize that these traditional housing value factors do not fully explain housing prices because they do not consider walkability. Therefore, the second stage of our regression takes the following form:

$$\varepsilon = f(\text{walkability}). \quad (4)$$

The results of our regressions are shown in Exhibit 14. These results indicate that market prices increase with home size and population change but decrease as the age of the home increases. Further, walkability does appear to explain some of the remaining variability in housing prices.

Exhibit 15 | Tests for Structural Changes

	2005 Sales	2006 Sales	2007 Sales	2008 Sales
Intercept	9.8928 (52.06***)	9.8769 (59.79***)	9.7484 (52.20***)	9.7230 (35.35***)
lnWalkScore	0.1174 (10.54***)	0.0906 (9.04***)	0.1044 (9.62***)	0.1323 (7.66***)
lnStructAge	−0.1726 (−13.46***)	−0.1687 (−15.29***)	−0.1860 (−15.42***)	−0.1938 (−9.40***)
lnSqFt	0.2314 (11.79***)	0.2389 (14.04***)	0.2618 (13.58***)	0.2655 (9.38***)
PopGrowth	0.0340 (3.36***)	0.0565 (6.46***)	0.0438 (4.38***)	0.0420 (2.80***)
F-statistic	85.24***	134.66***	107.88***	42.25***
R^2	0.2105	0.2784	0.2515	0.2281
N	1,284	1,401	1,289	577

Notes: This table presents the results for individual regressions by transaction year. *t*-statistics are shown in parentheses. The dependent variable in each model is *lnsalesprice*.

*The difference between the mean values across the two samples is significant at the 10% level.

**The difference between the mean values across the two samples is significant at the 5% level.

***The difference between the mean values across the two samples is significant at the 1% level.

After establishing a relationship between housing prices and walkability, that is, that housing prices marginally increase with walkability, we aim to determine if this relationship is constant over time. Recalling that our data covers the five-year period from 2004 to 2008, we estimate our model separately for each year and then conduct a Chow test to test for structural changes. That is, we test for parameter drift. The results of the regressions and the Chow test ($F = 5.82$) indicate that the coefficients do change over time. This suggests that it is possible that the degree to which walkability influences housing prices changes over time. Exhibit 15 presents the results.

These regressions show that the relationship between walkability and housing prices is fairly stable over the sample period.

Conclusion

We examine land values and Walk Scores for a sample of properties in Jefferson County, Alabama. Our aim in this analysis was to determine whether or to what extent, the benefits of walkable neighborhoods are reflected in land values. We find evidence that land values increase with walkability as measured by Walk Scores. The relation appears to be strongest in the most walkable neighborhoods, where Walk Score is above average for the MSA. In our data, these neighborhoods are found closer to the central business district (CBD), in older communities, and around universities. We argue that neighborhoods that are farther away from the CBD are not expected to be walkable and thus walkability is not a factor in land value. When we examine the degree to which property values are driven by land values, we again find that walkability matters. That is, land leverage also increases with walkability. We find similar results when using sales prices as opposed to land values.

The policy implications of these findings relate to initiatives to promote mixed-use developments and sustainable communities. Neighborhoods that include a mixture of retail/commercial and residential properties potentially provide features and benefits that promote the general well-being of the residents. These findings suggest that walkability adds value from a financial perspective, which may be attractive to developers and policymakers considering investment in mixed-use developments. Zoning that encourages mixed-use land developments will certainly result in higher land values and lower carbon footprints for such communities. Inner city developments in established older neighborhoods with better access to multiple amenities and work are more of a challenge to developers because of the parcel accumulation challenges and the lack of scale but certainly offer the potential for high walkability scores and positive incremental land value. Municipalities seeking higher property tax revenues should encourage such inner city mixed-use development by easing regulatory hurdles or speeding up the permitting process.

Endnotes

[1] We define consumption amenities according to Weissbourd, Bodoni, and He (2009) as related to the range of consumption options available to neighborhood residents, such as retail services, museums, dining, etc.

[2] There are currently 114 cities with Transit Scores. These are cities where the public transit agencies make their data available in an open format.

[3] This time period was selected because it was the most recent data available at the time of the study.

[4] We do not have data regarding whether or not the properties are attached or detached.

[5] For specific information about the Walk Score Algorithm methodology, see www.walkscore.com/rankings/ranking-methodology.shtml.

[6] In our analysis, population density was not consistently, positively correlated with land values as in the results shown here. We hypothesize that this lack of consistency with the Walk Score results indicates that Walk Score measures more than proximity despite the fact that Walk Scores are generally higher in more heavily populated areas. The full results of this analysis are not reported in the paper but are available upon request.

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