# The Premium for Walkable Development under Land Use Regulations

Emily Hamilton and Eli Dourado

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## ABSTRACT

This paper builds on the existing literature on the relationship between walkability and house prices. We demonstrate a positive relationship between home prices and walkability using zip code–level data in the first nationwide study of walkability. We find that a one-point increase in Walk Score commands a 0.14 percent price premium. In other words, a zip code with a Walk Score of 100 could be expected to command a 14 percent premium relative to an otherwise comparable zip code with a Walk Score of 0. Our findings indicate that land use regulations that prevent walkable development—such as zoning, parking requirements, and density restrictions—make consumers worse off by restricting choice and the supply of walkable neighborhoods that consumers are willing to pay a premium for.

JEL codes: R31, R38

Keywords: Walkability, Walk Score, Housing Supply, House Prices, Zoning, Land Use Regulation



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Critics of urban planning practices such as Smart Growth and New Urbanism often argue that regulations are forcing higher population densities than those a free market would produce. Smart Growth and New Urbanism are planning platforms that espouse urban infill development to accommodate growing populations in lieu of new greenfield development on city fringes. Joel Kotkin typifies this view when he writes that "planners and powerful urban land interests continue to force ever higher-density development down the throats of urban dwellers."[1] Kotkin is correct that some Smart Growth advocates do promote regulations that require higher population density than an unregulated market might support. As an example, the Environmental Protection Agency claims that density's benefits range from improved air and water quality to greater economic development.[2]

However, Kotkin's argument ignores that while relatively new land use practices such as binding urban growth boundaries and minimum density rules require greater population density than the free-market counterfactual, most land use regulations work in the opposite direction, limiting building and population density. Minimum lot size requirements, maximum residential density limits, parking requirements, and other traditional zoning regulations all lead to less dense development than the free market would produce.

Policy analyst Randall O'Toole shares Kotkin's view and argues that, based on survey data, consumers prefer less dense development in the form of detached single-family homes.[3] O'Toole cites surveys finding that, all else equal, most Americans prefer single-family homes with private yards to multifamily housing. He says that Smart Growth policies such as upzoning—liberalizing current

1. Joel Kotkin, "City Leaders are in Love with Density, but Most City Dwellers Disagree," *New Geography*, September 16, 2013.
2. Environmental Protection Agency, "Smart Growth," November 28, 2017, http://www2.epa.gov/smartgrowth.
3. Randal O'Toole, "How Urban Planners Caused the Housing Bubble," (Policy Analysis No. 646, Cato Institute, Washington, DC, October 1, 2009).

regulations that restrict residential density—make consumers worse off because Americans prefer low-density housing. However, survey data is not always a good indicator of the tradeoffs consumers face in the marketplace. While in the abstract people may prefer a single-family house on a large lot to an apartment, this isolated preference fails to take into account the many attributes of housing, including size, location, and access to amenities, that consumers must weigh when choosing where to live. For example, consumers have demonstrated their willingness to pay above-median rents for micro-apartments in new buildings in prime locations.[4]

Suppliers in the housing market are not free to build cities that reflect the demands of both walking people and car people in proportion to their numbers, and as a result consumers don't face the housing choices that would be available to them in a free market. We can't look at consumer decisions in a heavily regulated market as clear evidence of their revealed preferences.

Urban planning professor Jonathan Levine addresses the difficulty of gleaning information about consumer preferences in markets where land use regulations restrict allowable types of development and may prevent developers from building the type of housing their customers prefer. He designed a study to compare variation in consumer preferences with development variation across Boston, Massachusetts, a city with a relatively flat distribution of neighborhood types from central-city walkable neighborhoods to auto-oriented exurbs, and Atlanta, Georgia, a city where over 60 percent of homes are in exurban neighborhoods.[5] Levine surveyed residents of each city about their preferences for tradeoffs in housing choices, for example whether they would choose to live in a neighborhood with only single-family homes if this meant they would not have access to good public transportation. He found that, in Boston, people in the top decile for preferences of transit and pedestrian access had an 83 percent chance of living in an urban neighborhood or an inner suburb. In Atlanta, the people in the highest decile of stated preferences for walkable urban neighborhoods had a 52 percent chance of living in an outer suburb or an exurb.[6] He explains, "Relative lack of choice in Atlanta rendered one's neighborhood selections much less sensitive to one's preferences than in Boston."[7]

4. Laura Kusito, "Builders Bet Tiny Apartments Will Lure Renters," *Wall Street Journal,* April 15, 2017.
5. Jonathan Levine, *Zoned Out: Regulation, Markets, and Choices in Transportation and Metropolitan Land-Use* (New York: Resources for the Future, 2006), 153.
6. Levine, *Zoned Out*, 161.
7. Levine, *Zoned Out*, 165.

It is true that some Smart Growth planners might like to require people to live in dense apartment buildings and forgo driving cars,[8] but it is also true that, today, every city of significant size in the United States enforces zoning rules that restrict urban density, including minimum parking requirements, benefiting drivers at the expense of walkers and limiting development density.[9] While Smart Growth regulations like maximum parking limits and minimum density limits are beginning to emerge in select cities, traditional zoning rules that restrict development density remain much more common.[10]

Because a complicated web of regulations currently governs development in US cities and some of these regulations act at cross-purposes, determining whether or not urban planning policies ultimately result in more or less density than the free market would provide is an empirical question. One could reasonably hypothesize that the net effect of regulations is to shape cities that are either more urban (dense, mixed-use, walkable) or more suburban (less dense, single use, driveable).

A key tradeoff between more and less dense development is ease of various types of transportation. In less dense, suburban development, parking is often available at zero-price, facilitating ease and affordability of driving between destinations. However, the development patterns that result in ease of driving typically reduce walkability. Surface parking lots increase the distance between destinations, creating an environment in which pedestrians have longer and less pleasant paths to traverse if they want to walk rather than drive. Wide streets that facilitate more cars traveling at higher speeds make conditions less pleasant and more dangerous for pedestrians.

Given that many American cities may have an undersupply of walkable neighborhoods relative to consumer preferences, we must look to the prices people pay to live in various types of neighborhoods to determine whether land use regulations make cities more or less dense and walkable than they would be absent regulations. These revealed preferences are a more reliable indicator of consumers' preferences than survey data that participants provide without having to live with their decisions.

8. For example, Portland has some neighborhoods with minimum density requirements. See Michael Lewyn and Kristoffer Jackson, "How Often Do Cities Mandate Smart Growth or Green Building?" (Mercatus Working Paper, Mercatus Center at George Mason University, Arlington, VA, October 2014).
9. For a detailed study of the costs of parking requirements, see Donald Shoup, *The High Cost of Free Parking* (Chicago: American Planning Association, 2005).
10. Lewyn and Jackson. "How Often Do Cities Mandate Smart Growth or Green Building?"

In this paper we estimate the relationship between walkability and home prices to determine whether land use regulations that limit walkability are making consumers better or worse off. First we review the existing literature on walkability and house prices. Second, we discuss our estimate of the walkability premium, finding that consumers are willing to pay a statistically significant premium to live in more walkable neighborhoods. Third, we discuss the policy implications of our empirical findings.

## LITERATURE REVIEW

Real estate economics has a long history of empirical study, including efforts to quantify the contributions of both location and housing quality to real estate prices. For a review of some of the large body of work on housing price determinants, see Phuong Nguyen-Hoang and John Yinger.[11] Since the 1980s, researchers have also pursued empirical studies on the relationship between housing prices and urban form.

Early studies in this line of research tested whether or not Euclidean zoning, separating housing from other land uses, made consumers better or worse off as revealed through consumers' housing choices. D. M. Grether and Peter Mieszkowski start with the research question, "Do zoning regulations achieve their stated intent of protecting the value of single-family homes from the externalities of other land uses?"[12] They find that commercial and multifamily uses have no impact on the prices of nearby single-family homes in New Haven while heavy industrial uses and public housing do reduce the price of single-family homes relative to other comparable homes. In a similar study of land use mixing, Than Van Cao and Dennis Cory emphasize that mixed-use development has both positive and negative externalities for residential development.[13] However, in their study of Tucson, Arizona, they find that commercial and industrial real estate tend to increase the value of single-family homes, indicating that zoning holds mixed land uses below the optimal level.

More recent empirical studies of land use regulations have the advantage of Geographic Information Systems (GIS), which allows for more precise and broader spatial econometric studies that can attempt to measure the value of

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11. Phuong Nguyen-Hoang and John Yinger, "The Capitalization of School Quality into House Values: A Review," *Journal of Housing Economics* 20, no. 1 (2011).
12. David M. Grether and Peter Mieszkowski, "The Effects of Nonresidential Land Uses on the Prices of Adjacent Housing: Some Estimate of Proximity Effects," *Journal of Urban Economics* 8, no. 1 (1980): 7–14.
13. Grether and Mieszkowski, "Effects of Nonresidential Land Uses," 12–13.

neighborhood walkability. Yan Song and Gerrit Knapp have conducted multiple studies of walkability in Portland, Oregon.[14] Like Van Cao and Cory, they find that proximity to nonresidential amenities increases the value of single-family homes. They find that while multifamily housing and industrial uses may lower home values, service-oriented businesses and parks increase home values.

Outside of zoning rules, the work of urban planners and civil engineers has a complex impact on home values. Infrastructure can be designed to facilitate pedestrian activity, making a neighborhood more walkable, or it can be designed to facilitate easier driving transport. Either has the potential to increase home values, depending on consumers' preferences. Christopher B. Leinberger and Mariela Alfonzo at the Brookings Institution undertook a study of walkability in Washington, DC, in 2012.[15] They determine that housing in highly walkable neighborhoods in the DC area is more expensive on average than that in less walkable neighborhoods. Their findings indicate a revealed preference for mixed-use neighborhoods in which residents can walk from their homes to a variety of amenities over suburban-style development in which driving is easier. They explain,

> The apparent supply-demand mismatch for walkable places may be contributing significantly to the price premium these places demand. To the extent that this is the case, the short and medium-term shortage of walkable places makes them inaccessible (unaffordable) to many people who desire to live in such places.[16]

Leinberger and Alfonso conducted their study by gathering data on the walkability of 201 neighborhoods in the DC area. While this approach has advantages, it is costly and can be conducted only in a relatively small number of neighborhoods at a time. In contrast, Walk Score provides an index that approximates walkability by city, neighborhoods, zip code, and address. Founded in 2007, the company Walk Score rates locations according to the average distance to commercial amenities from residential origins.

The ranking is designed to demonstrate how easy it is for a resident to run errands, go to restaurants, and enjoy entertainment without a car. The Walk Score algorithm uses several characteristics of neighborhoods to determine how

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14. Yan Song and Gerrit Knapp, "New Urbanism and Housing Values: A Disaggregate Assessment," *Journal of Urban Economics* 54, no. 2 (2003); Yan Song and Gerrit Knapp, "Measuring the Effects of Mixed Land Uses on Housing Values," *Regional Science and Urban Economics* 34 (2004).
15. Christopher B. Leinberger and Mariela Alfonzo, "Walk This Way: The Economic Promise of Walkable Places in Metropolitan Washington, DC" (Metropolitan Policy Program, Brookings Institute, Washington, DC, May 2012).
16. Leinberger and Alfonzo, "Walk This Way," 12.

friendly they are to pedestrians, including residential distance to amenities and street connectivity, and provides locations with a fixed score from 0 to 100. Walk Score provides scores for cities by calculating walkability at different points and weighting these measurements by population densities. The Walk Score algorithm builds on the progress of GIS to make walkability research across cities cheaper and, potentially, more accurate.

Despite its advantages, some researchers have criticized Walk Score's methods for not including all the variables thought to influence walkability. For example, Walk Score ratings do not take into account sidewalk width, topography, crime, or weather, all of which may influence how much people choose to walk in a given neighborhood and how much they rely on cars. A key failing of the original Walk Score metric is that it measured distances as the crow flies rather than as a pedestrian would actually be able to walk. This leads to significant inaccuracy in Walk Score's correlation to walkability in cases such as a residential area separated from a shopping center by a highway. The creators of Walk Score have developed a new metric called Street Smart Walk Score that determines access to amenities based on the actual routes available to pedestrians. In our research, however, we use data collected in 2012, before the Street Smart Walk Score was available.

In spite of Walk Score's limitations, several researchers have validated Walk Score as a good indicator of how much a neighborhood's residents actually do walk in daily life. Lucas J. Carr, Shira I. Dunsiger, and Bess H. Marcus followed Walk Score's methodology to manually calculate scores for 379 Rhode Island addresses using GIS to test whether or not the original Walk Score algorithm accurately reflected opportunities to walk to destinations from a given starting point. They find a high degree of accuracy for Walk Score's algorithm, concluding that

> Walk Score [is] a reliable and valid measure of estimating access to walkable amenities. Walk Score may be a convenient and inexpensive option for researchers interested in exploring the relationship between access to walkable amenities and health behaviors such as physical activity.[17]

In a Masters of Public Health thesis, Lindsey Jones tests the relationship between Walk Score and physical activity.[18] Jones finds no significant relationship

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17. Lucas J. Carr, Shira I. Dunsiger, and Bess H. Marcus, "Walk Score as a Global Estimate of Neighborhood Walkability," *American Journal of Preventive Medicine* 39, no. 5 (November 2010).
18. Lindsey Jones, "Investigating Neighborhood Walkability and its Association with Physical Activity Levels and Body Composition of a Sample of Maryland Adolescent Girls" (master's thesis, University of Maryland, 2010).

between Walk Score and physical activity, but in the same study she determines that Walk Score is correlated with GIS-derived indices of walkability using the most accepted formula in walkability literature, which defines walkability as a function of intersection density, residential density, and the mix of building uses. In contrast, Dustin T. Duncan and his coauthor find some limitations to Walk Score's correlation with GIS-derived walkability measures:

> The correlations between Walk Score and cul de sac count overall were moderate and significant at the 1600-meter buffer level, which . . . underscores that Walk Score is not a useful proxy for overall neighborhood walkability. We also found significant moderate correlations between Walk Scores and average speed limit as well as Walk Scores and highway density overall, which may also hinder one's ability to walk in their neighborhood. Therefore, our findings indicate that Walk Score is a useful proxy for only certain neighborhood walkability indicators (e.g., retail destinations, intersection density, residential density).[19]

In spite of these limitations, Walk Score provides an important research tool by providing an inexpensive and simple measure of walkability relative to on-the-ground estimations that are difficult and time consuming to construct. The introduction of Walk Score has facilitated more research on walkability as both an independent and a control variable in recent years. Kevin Manaugh and Ahmed El-Geneidy provide an overview of research that has used Walk Score to date. Several past studies have used Walk Score data to study consumer preferences for walkability.[20] For example, Price Armstrong and Jessica Greene looked at the causal effect of Walk Score, crime, year sold, home type, neighborhood, acreage, and square footage on home sale prices in Gresham, Oregon.[21] Their findings refuted their hypothesis that Walk Score and house prices would be positively correlated; instead they found a negative correlation between Walk Score and

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19. Dustin T. Duncan et al., "Validation of Walk Score® for Estimating Neighborhood Walkability: An Analysis of Four US Metropolitan Areas," *International Journal of Environmental Research and Public Health* 8 (2011): 4173.
20. Kevin Manaugh and Ahmed El-Geneidy, "Validating Walkability Indices: How Do Different Households Respond to the Walkability of the Neighborhood?" *Transportation Research Part D: Transport and Environment* 16, no. 4 (2011).
21. Price Armstrong and Jessica Greene, "Sustainability Focused Data Analysis: To What Extent Do Walkability, Crime, and Neighborhood Predict Housing Prices?" (Sustainable Cities Initiative, University of Oregon, 2009).

home values. This result contrasts with Song and Knapp's results from neighboring Washington County.

Stephanie Yates Rauterkus and Norman Miller use Walk Score to conduct a study of prices in Jefferson County, Alabama.[22] They study land prices, more directly measuring the value of walkability than as it is reflected in house prices, as walkability does not, of course, contribute to house values outside the location of the land the house sits on. They determine that neighborhoods with higher Walk Scores have higher land values and that this effect is larger in neighborhoods that are more walkable. While the study focuses on land values, the authors find this result is mirrored in home prices.

Other studies have used Walk Score to estimate the walkability premium in a sample of cities. In a study of 15 metropolitan areas, Cortright finds that home buyers place a significant premium on neighborhoods with above-average walkability in a hedonic regression.[23] He finds that an additional point in Walk Score can be expected to raise home values by $700 to $3,000. In *Zillow Talk: Rewriting the Rules of Real Estate,* Spencer Rascoff and Stan Humphries estimate the price premium for a 15-point increase in Walk Score across 15 cities. They find that this increase in walkability accounts for an average increase in home prices of 12 percent, with a range of 4 percent to 24 percent across the markets they studied.[24] They find that the value of additional walkability is greater in more walkable cities.

Austin Boyle, Charles Barrileaux, and Daniel Scheller critique some of these studies as identifying a spurious correlation between Walk Score and home prices.[25] They argue that past research on walkability, such as Cortright's study, ignores neighborhood effects: "controlling for neighborhood is important because it separates the effect of walkability from the effect of living in a better neighborhood."[26] In their study of the relationship between Walk Score and assessed home values in Miami, Florida, they find a positive correlation using OLS regression but no relationship after adding neighborhood-level fixed effects.

22. Stephanie Yates Rauterkus and Norman Miller, "Residential Land Values and Walkability," *Journal of Sustainable Real Estate* 3, no. 1 (2011).
23. Joe Cortright, *Walking the Walk: How Walkability Raises Home Values in U.S. Cities* (Cleveland: CEOs for Cities, August 2009).
24. Spencer Rascoff and Stan Humphries, *Zillow Talk: The New Rules of Real Estate* (New York: Grand Central, 2015).
25. Austin Boyle, Charles Barrileaux, and Daniel Scheller, "Does Walkability Influence Housing Prices?," *Social Science Quarterly* 95, no. 3 (2014).
26. Boyle, Barrileaux, and Scheller, "Does Walkability Influence Housing Prices?"

Most studies relating Walk Score to home prices focus on small geographical areas or a small sample of cities. This offers the advantage of being able to control for property attributes that would be prohibitively costly to control for in a nationwide study, such as crime, property taxes, and public services. Similarly, the neighborhood-level fixed effects that Boyle, Barrilleaux, and Scheller employ would be difficult to replicate in a national sample of cities. However, studying the importance of Walk Score in select cities also carries the risk that the findings in one city are not generalizable to other real estate markets. For example, if the walkable neighborhoods in Gresham, Oregon, happen to all be located in parts of the city that are located far from job centers, this could explain why residents are not willing to pay more for houses located in walkable neighborhoods and may explain the varying results between studies of Washington County and Gresham despite their proximity. Additionally, existing studies of walkability demonstrate a trend toward studying relatively walkable cities like Washington, DC, with a Walk Score of 77 (defined as Very Walkable) and Portland with a Walk Score of 65 (defined as Somewhat Walkable).[27] Walk Score does not publicly provide a weighted Walk Score of Jefferson County, Alabama, but Rauterkus and Miller describe it as one of the most walkable areas in the state.[28]

Localized studies offer some advantages that are not possible on a larger scale. For example, researchers can develop their own metrics for walkability, which may be more inclusive and accurate than Walk Score. Additionally, data collection at the municipal level may not be consistent across municipalities. For example, some cities notoriously underreport crime, an important factor in home prices. If this problem is consistent among neighborhoods within a city, it may not result in biased estimates of the value of walkability. However, when using multiple cities as data points, this will lead to biased estimates of walkability.

Despite the challenges of studying the value of walkability on a nationwide level, this research remains critical to informing the land use policies that determine what developers can build for their consumers. Portland, Oregon, is one of the most heavily studied cities with regard to walkability, but its urban growth boundary means that results from Portland may not be generalizable to other cities. A much broader study of the country's diverse cities will help to determine if this relationship holds up over cities of broader ranges of walkability.

27. These were the Walk Scores of Washington and Portland as of November 1, 2017. See https://www.walkscore.com/.
28. Rauterkus and Miller, "Residential Land Values."

One study of walkability in the United States has approached the walkability issue at a national level. Gary Pivo and Jeffrey Fisher study a representative sample of commercial buildings in the United States.[29] Their sample includes retail, office, apartment, and industrial buildings. They determine that walkability results in higher values for all of these types of assets except for industrial properties, for which walkability does not command a premium. They control for variables including building age and size, occupancy rate, population density, crime, transit accessibility, and commute time.

In 2013 we used Walk Score data to publish the first nationwide study of the relationship between walkability and home values.[30] I found that a one-point increase in Walk Score correlates with a 0.5 percent increase in house prices, indicating that consumers are willing to pay a premium to live in more walkable neighborhoods even though these neighborhoods may come with the drawback of being less convenient for driving and parking. These findings indicate that land use regulations that restrict the supply of walkable housing may be making consumers worse off.

## DATA

Our independent variable of interest is the zip code–level Walk Score. We used a web scraping tool to gather Walk Score data for all of the zip codes in core-based statistical areas (CBSAs) in 2012. The Census designation CBSA includes all the zip codes in micropolitan or metropolitan statistical areas, or in other words, all the zip codes that are not rural. We selected zip code as our unit of analysis because of its availability through Walk Score and the feasibility of gathering a national sample.

Walk Score provides the zip code score by calculating the score at the zip code's geographic center. For a single zip code, this score at the geographic center (centroid) may differ significantly from what the zip code's weighted score would be. Over our large sample, we expect that our observed zip code centroid Walk Score is highly correlated with each zip code's unobserved weighted score. One potential limitation of using Walk Score to measure walkability is that, in addition to capturing pedestrian access to commercial destinations, it also captures proximity to these amenities. Our estimates on the coefficient of Walk

29. Gary Pivo and Jeffrey Fisher, "The Walkability Premium in Commercial Real Estate Investments," *Real Estate Economics* 39, no. 2 (2011).
30. Emily Washington (now Hamilton), "The Role of Walkability in Driving Home Values," *Leadership and Management in Engineering* 13, no. 3 (July 2013).

Score may reflect a preference for close access to amenities by any mode of transportation rather than walkability per se.

An additional limitation of our dataset is that we're working with zip code median data for our independent and dependent variables. While this approach gives us the ability to collect a nationwide dataset, it also eliminates important variation in walkability, house prices, and our control variables such as number of variables and commute time. We make the tradeoff of accepting this limitation for the potential of a nationwide dataset. Using zip code averages introduces attenuation bias into our regressions, which would make our estimated coefficient tend toward zero and our results insignificant. Because the results in our key regression are significant, we do not attempt to correct for this possible attenuation.

Aside from Walk Score, our independent variables include number of rooms, age of housing, average commute time, zip code distance from the nearest Central Business District (CBD), average income, vacancy rate, and population density. These zip codes are spread across 539 CBSAs in 738 counties. Our control variables for population density, average rooms, average age of buildings, average commute times, average income, and vacancy rate come from the Zip Code Tabulation Area data in the American Community Survey.[31] We also control for zip code distance to central business districts using a tool developed by Matthew Holian and Matthew Kahn.[32]

The dependent variable in our primary model is average per-square-foot house sale price from 2012, gathered from Zillow. For robustness, we also include a model with per-square-foot rental rates. These are also gathered from Zillow and reflect 2012 data. While Zillow provides the best available nationwide dataset of average housing values at the zip code level, for our 2012 sample only 3,221 data points are available for home prices, and 5,956 data points are available for rental rates. Thus, the data for our dependent variable constrains our sample size.

31. The American Community Survey data are presented as percentages of households in various ranges. For example, the lowest household income range is from 0 to $10,000, and the highest is $200,000 or higher. To use the data, we created weighted averages using the median of each band where possible ($5,000 in the case of the lowest income band and $200,000 in the case of the highest band where it's not possible to use a median income for the range). For many zip codes, this method of estimation is downwardly biased for average rooms, average commute, average income, and average age of homes. While these estimates may be problematic for a study of these characteristics of zip codes, we do not think that relatively minor downward bias in these measurements affects our general finding of a positive relationship between median house prices and Walk Score.
32. Matthew J. Holian and Matthew E. Kahn, "Household Carbon Emissions from Driving and Center City Quality of Life," *Ecological Economics* 116 (2015): 362–68.

Hedonic regressions of home prices often include variables on public amenities and disamenities such as public school quality and crime. Unfortunately, nationwide data on these control variables isn't available at the zip code level. Our key regressions include county-level fixed effects that control for these variables at the level of this jurisdiction. An alternative would be to use CBSA fixed effects. CBSAs include metropolitan and micropolitan statistical areas, regions defined by the Office of Management and Budget based on regional economic ties. We rely on county-level fixed effects rather than CBSA-level fixed effects because of the ability to better control for policy variables at the county level while still accounting for the labor market control that the CBSA-level control would provide. We do include a CBSA-level fixed-effects specification as a robustness check.

We have a cross-sectional sample of data, all from 2012. The mean Walk Score is 17.2, and the mean estimated Zillow price per square foot is $166.99. See table 1 for all our summary statistics.

## MODEL

In this paper we improve on the estimate of the walkability premium found in Washington's 2013 paper.[33] We use a fixed-effects model to test our hypothesis that consumers pay a premium to live in walkable neighborhoods. Unlike the studies cited in our literature review, our unit of observation is zip codes. Our dependent variable is the median per-square-foot home sale price at the zip code level.

Based on the widespread use of land use regulations that restrict the supply of walkable development, we hypothesize that consumers pay a premium to live in walkable zip codes. We begin with a simple OLS model testing the relationship between Walk Score and housing prices at the zip code level. In our first specification, with a sample of 2,995 zip codes, we use

$$\ln P_i = \beta_0 + \beta_1 W_i + \beta_2 D_i + \beta_3 N_i + \beta_4 C_i + \beta_5 T_i + \beta_6 I_i + \beta_7 A_i + \beta_8 V_i + \epsilon_i,$$

where $P$ is per-square-foot sale price, $W$ is Walk Score, $D$ is population density, $N$ is average number of rooms, $C$ is the zip code centroid's distance to the center point of its nearest CBD, $T$ is average commute time, $I$ is average income, $A$ is the average age of houses, and $V$ is the vacancy rate. In this regression, we find a statistically insignificant relationship between Walk Score and home prices.

33. Holian and Kahn, "Household Carbon Emissions."

TABLE 1. SUMMARY STATISTICS

| Variable | Observations | Mean | Standard Deviation | Minimum | Maximum |
|---|---|---|---|---|---|
| Walk Score | 25,399 | 17.21 | 24.27 | 0 | 100 |
| Total units | 25,385 | 4,870.10 | 5,973.71 | 0 | 47,418 |
| Vacant units | 25,385 | 569.21 | 898.72 | 0 | 27,236 |
| Population | 25,385 | 11,618.49 | 14,839.33 | 0 | 115,538 |
| Area (square miles) | 24,044 | 69.41 | 154.0032 | 0.003 | 5,496.192 |
| Population density (residents per square mile) | 24,044 | 1,600.46 | 6,005.40 | 0 | 405,750 |
| Price per square foot | 3,221 | 166.99 | 135.8 | 16.57 | 1,921.62 |
| Rent per square foot | 5,956 | 1.15 | 1.42 | 0.078 | 75 |
| Average rooms | 25,053 | 5.75 | 0.78 | 1 | 9 |
| Average commute | 25,050 | 27.84 | 7.53 | 0 | 90 |
| Average income | 25,000 | 56,954.3 | 14,140.14 | 200 | 174,999.5 |
| Average age | 25,053 | 41.17 | 11.50 | 7 | 73 |
| Average vacancy rate | 25,053 | 0.15 | 0.15 | 0 | 1 |

The coefficients on density and average income are significant in the expected directions. The coefficients on distance from the CBD, average commute, and vacancy rate are insignificant. The coefficient on average age is positive and significant while we would expect consumers to pay more for newer homes than older homes, all else equal. Our full regression results are reported in table 2.

This specification has the obvious problem of not controlling for job market opportunities and other location-specific amenities and disamenities that are capitalized into the median home prices of zip codes, including labor market opportunities, cost of living, geography, public policy, etc. We believe that, because some of the country's most walkable cities are also some of the most productive cities[34] and they offer some of the most desirable consumption amenities,[35] this estimate results in a downward bias on the coefficient for Walk Score. A fixed-effects model is the appropriate way to deal with the observable and unobservable factors that affect housing prices based on the jurisdiction that the house is located in. Starting with the same specification in the OLS model above, we add a fixed-effects model with 375 counties:

$$\ln P_{ij} = \beta_0 + \beta_1 W_{ij} + \beta_2 D_{ij} + \beta_3 N_{ij} + \beta_4 C_{ij} + \beta_5 T_{ij} + \beta_6 I_{ij} + \beta_7 A_{ij} + \beta_8 V_{ij} + \epsilon_i .$$

34. Chang Tai-Hsieh and Enrico Moretti, "Housing Constraints and Spatial Misallocation" (Berkeley Working Paper, forthcoming).
35. Edward Glaeser, *Triumph of the City: How Our Greatest Invention Makes Us Richer, Smarter, Greener, Healthier, and Happier* (New York: Penguin, 2011), 242.

TABLE 2. ORDINARY LEAST SQUARES REGRESSION RESULTS

| Log Zillow Price Per Square Foot | Coefficient | Robust Standard Error | *t* | *P*>*t* | [95% Confidence Interval] | |
|---|---|---|---|---|---|---|
| Walk Score | 0.00036 | 0.00055 | 0.7 | 0.49 | –0.0007 | 0.0015 |
| Density | 0.000017 | 2.20E-06 | 7.64 | 0 | 0.000013 | 0.000022 |
| Average rooms | –0.33 | 0.047 | –7.08 | 0 | –0.42 | –0.24 |
| Distance (kilometers) | 0.00016 | 0.0011 | 0.14 | 0.89 | –0.002 | 0.0023 |
| Average commute | 0.0037 | 0.0042 | 0.88 | 0.38 | –0.0045 | 0.012 |
| Average income | 0.00004 | 0.0000023 | 17.11 | 0 | 0.000035 | 0.000045 |
| Average age | 0.015 | 0.0024 | 6.36 | 0 | 0.01 | 0.02 |
| Vacancy rate | 0.46 | 0.26 | 1.78 | 0.076 | –0.047 | 0.96 |
| Constant | 3.54 | 0.22 | 16.18 | 0 | 3.11 | 3.97 |

Note: Number of observations = 2,995; $F(8, 374) = 109.1$; Probability > $F = 0$; $R$-squared = 0.51; Root MSE = 0.41; Standard error adjusted for 375 clusters in county.

As anticipated, here Walk Score's coefficient is positive at 0.11 percent and highly statistically significant. The R-squared here is 0.83, indicating that, with the addition of the county-level fixed effects, our model explains the majority of the variation in housing prices. We don't have a strong hypothesis about whether or not average rooms should be positively correlated with price (people may prefer more rooms or more open floor plans), but our other coefficients have the expected sign with the exception of vacancy rate and average age, which both have unexpected positive signs. In the case of vacancy rate, this may be because some zip codes with very high vacancy rates also tend to be zip codes where a large percent of housing is vacation homes. Again, we find a positive, statistically significant estimate of the relationship between the average age of housing and average per-square-foot prices. All else equal, we would expect people to be willing to pay more for newer housing. Our finding of the opposite relationship may be a result of desirable characteristics of older neighborhoods that are not fully captured by Walk Score. The full results of this fixed-effects specification are reported in table 3.

Following Rascoff and Humphries, we believe the relationship between Walk Score and home prices may be nonlinear; an additional point of walkability may be worth more in relatively walkable neighborhoods than in neighborhoods where most trips need to be made by car. To test for this nonlinearity, we use the fixed-effects specification above using only the observations in our sample that have a Walk Score of 70 or higher, what Walk Score defines as Very Walkable. For this sample, we estimate that an additional point of Walk Score corresponds with a 0.56 percent increase in per square foot home prices. Our full regression results

TABLE 3. FIXED EFFECTS REGRESSION RESULTS

| Log Zillow Price Per Square Foot | Coefficient | Robust Standard Error | $t$ | $P>t$ | [95% Confidence Interval] | |
|---|---|---|---|---|---|---|
| Walk Score | 0.0011 | 0.00036 | 2.92 | 0.004 | 0.00034 | 0.0018 |
| Density | 0.0000037 | 0.0000036 | 1.03 | 0.3 | –0.0000034 | 0.000011 |
| Average rooms | 0.02 | 0.027 | 0.76 | 0.45 | –0.032 | 0.073 |
| Distance (kilometers) | –0.0035 | 0.0012 | –2.97 | 0.003 | –0.0059 | –0.0012 |
| Average commute | –0.029 | 0.0033 | –8.8 | 0 | –0.036 | –0.023 |
| Average income | 0.000018 | 0.0000019 | 9.31 | 0 | 0.000014 | 0.000022 |
| Average age | 0.004 | 0.00095 | 4.19 | 0 | 0.0021 | 0.0058 |
| Vacancy rate | 1.22 | 0.31 | 3.93 | 0 | 0.61 | 1.83 |
| Constant | 4.3 | 0.17 | 25.46 | 0 | 3.97 | 4.63 |

Note: County absorbed (375 categories). Number of observations = 2,995; $F(8, 374) = 47.20$; Probability > $F$ = 0.0000; $R$-squared = 0.85; Adjusted $R$-squared = 0.83; Root MSE = 0.25; Standard error adjusted for 375 clusters in county.

are reported in table 4. Based on this finding, our results in table 3 understate the effect of Walk Score on price in Very Walkable neighborhoods but overstate it in neighborhoods with lower walkability.

We include two models to test our results for robustness. First, we use rental rates as a dependent variable rather than sale prices. Using rental rates, we find an even larger coefficient on Walk Score, that a one-point increase in the zip code's average walkability corresponds with a 0.093 percent increase in rental rates, statistically significant at the 99 percent level. Finally, we use CBSAs as fixed effects rather than counties. We think that county fixed effects are appropriate because they provide a degree of control for public policy–driven amenities, such as public school quality and crime, factors with established effects on home prices. However, CBSAs have the benefit of being defined by organic labor markets rather than counties that tend to be larger in the West and smaller in the East. Using 178 CBSAs as the fixed effect rather than counties, we find that a one-point increase in Walk Score corresponds with a 0.061 percent increase in home prices. We report the full results of these robustness checks in tables 5 and 6.

We find evidence that, across a national sample, home buyers are willing to pay more for houses with higher Walk Scores. Our findings stand in contrast to Boyle, Barrilleaux, and Scheller's study of Miami, Florida, and Price and Greene's study of Gresham, Oregon. Boyle et al. argue that past work that has failed to control for neighborhood effects has identified a spurious correlation between home prices and Walk Score because people with high incomes both tend to purchase relatively expensive homes and tend to prefer to live in amenity-rich

**TABLE 4. FIXED EFFECTS REGRESSION RESULTS FOR OBSERVATIONS WITH WALK SCORE OF 70 OR HIGHER**

| Robust Log Zillow Price Per Square Foot | Coefficient | Robust Standard Error | *t* | *P*>*t* | [95% Confidence Interval] | |
|---|---|---|---|---|---|---|
| Walk Score | 0.0056 | 0.0031 | 1.79 | 0.076 | –0.00059 | 0.012 |
| Density | 0.000002 | 0.0000025 | 0.8 | 0.426 | –0.0000029 | 0.0000068 |
| Average rooms | –0.12 | 0.069 | –1.81 | 0.073 | –0.261 | 0.012 |
| Distance (kilometers) | –0.041 | 0.0077 | –5.37 | 0 | –0.056 | –0.026 |
| Average income | 0.00002 | 0.0000056 | 3.6 | 0.001 | 0.0000091 | 0.000031 |
| Average age | 0.0044 | 0.0032 | 1.34 | 0.182 | –0.0021 | 0.011 |
| Vacancy rate | 0.82 | 0.5 | 1.67 | 0.099 | –0.16 | 1.81 |
| Constant | 5.46 | 0.47 | 11.64 | 0 | 4.53 | 6.39 |

Note: County absorbed (98 categories). Number of observations = 380; $F(8, 374) = 23.04$; Probability > $F$ = 0.0000; $R$-squared = 0.9; Adjusted $R$-squared = 0.86; Root MSE = 0.26; Standard error adjusted for 375 clusters in county.

**TABLE 5. FIXED EFFECTS REGRESSION RESULTS FOR WALK SCORE ON RENTAL RATES**

| Log Rent | Coefficient | Robust Standard Error | *t* | *P*>*t* | [95% Confidence Interval] | |
|---|---|---|---|---|---|---|
| Walk Score | 0.00097 | 0.0001 | 4.92 | 0 | 0.00058 | 0.0014 |
| Density | 0.0000012 | 0.00000057 | 2.09 | 0.037 | 0.000000071 | 0.0000023 |
| Average rooms | –0.047 | 0.018 | –2.54 | 0.011 | –0.083 | –0.01 |
| Distance (kilometers) | –0.00054 | 0.00075 | –0.73 | 0.47 | –0.002 | 0.00092 |
| Average commute | –0.024 | 0.0021 | –11.3 | 0 | –0.028 | –0.02 |
| Average income | 0.0000075 | 0.0000009 | 8.37 | 0 | 0.0000058 | 0.0000093 |
| Average age | –0.0016 | 0.0007 | –2.28 | 0.023 | –0.003 | –0.00022 |
| Vacancy rate | 1.24 | 0.31 | 3.96 | 0 | 0.62 | 1.85 |
| Constant | 0.37 | 0.098 | 3.8 | 0 | 0.18 | 0.57 |

Note: County absorbed (623 categories). Number of observations = 5,512; $F(8, 622) = 53.65$; Probability > $F$ = 0; $R$-squared = 0.82; Adjusted $R$-squared = 0.79; Root MSE = 0.2; Standard error adjusted for 623 clusters in county.

neighborhoods that happen to have high Walk Scores. In our study, the unit of observation is the neighborhood, as defined by zip codes, so we do not run the risk of erroneously attributing house price differences to Walk Score rather than to neighborhood characteristics. After controlling for hedonic factors that affect median home prices across zip codes, we find that consumers place a premium on zip codes that are more walkable in a fixed-effects model. Our findings provide reason to question whether or not results on the price effect of walkability in a single city are generalizable.

TABLE 6. REGRESSION RESULTS USING COUNTY FIXED EFFECTS

| Log Price Per Square Foot | Coefficient | Robust Standard Error | *t* | *P* > *t* | [95% Confidence Interval] | |
|---|---|---|---|---|---|---|
| Walk Score | 0.00061 | 0.00035 | 1.77 | 0.078 | –0.00007 | 0.0013 |
| Density | 0.000014 | 0.0000031 | 4.51 | 0 | 0.000008 | 0.00002 |
| Average rooms | 0.00084 | 0.032 | 0.03 | 0.98 | –0.063 | 0.065 |
| Distance (kilometers) | –0.0039 | 0.00091 | –4.29 | 0 | –0.0057 | –0.0021 |
| Average commute | –0.028 | 0.0035 | –8.15 | 0 | –0.035 | –0.021 |
| Average income | 0.000019 | 0.0000025 | 7.79 | 0 | 0.000014 | 0.000024 |
| Average age | 0.004 | 0.0015 | 2.63 | 0.009 | 0.001 | 0.007 |
| Vacancy rate | 1.25 | 0.36 | 3.48 | 0.001 | 0.54 | 1.96 |
| Constant | 4.27 | 0.2 | 21.14 | 0 | 3.87 | 4.67 |

Note: CBSA absorbed (178 categories). Number of observations = 2,995; $F(8, 177) = 49.59$; Probability > $F$ = 0; $R$-squared = 0.1; Adjusted $R$-squared = 0.79; Root MSE = 0.27; Standard error adjusted for 178 clusters in CBSA.

## CONCLUSION

The relatively recent policy tools of urban growth boundaries, parking maximums, and minimum density requirements require developers to build more walkable development than they otherwise might. While critics of these Smart Growth policies correctly argue that policies requiring walkable development have the potential to distort the market and harm consumers, our study demonstrates that traditional zoning currently has a larger effect in restricting the supply of available walkable development. Because density restrictions, parking requirements, and setback requirements limit the availability of housing in walkable neighborhoods, consumers who prefer walkable development have to pay a premium for it. Walkable development is not without tradeoffs. Typically, walkable neighborhoods come at the expense of conveniences such as readily available parking, ample private yards, and peace and quiet. In spite of these downsides of walkable neighborhoods, consumers are willing to pay a premium to live in more walkable places.

This paper builds on Cortright, Song and Knapp, Leinberger and Alfonzo, Rascoff and Humphries, and Washington, providing further evidence that consumers value walkability and that, in a free market, we would see a larger supply of walkable development. Cortright finds that consumers pay $4,000 to $34,000 more for a home in a neighborhood of above-average walkability relative to homes in locations of average walkability. His findings are in line with our findings of the nationwide walkability premium, where we find that a one-point increase in Walk Score commands a 0.14 percent price premium. In other words, a $200,000 home in a neighborhood with a Walk Score of 0 could be expected to sell for $28,000 more in a neighborhood with a Walk Score of 100.

The walkability premium indicates that, on net, consumers would be better off with fewer regulations restricting the supply of walkable development, including parking requirements, setback requirements, and density restrictions. Because the current regulatory environment restricts the quantity of walkable development that home builders are allowed to provide, consumers pay a premium for this housing attribute that they value. Without these restrictions in place, home builders would face an opportunity to profit by increasing the supply of walkable development. This higher quantity of walkable housing would increase the number of people who are able to live in walkable neighborhoods and lower the premium they would have to pay for the privilege.

## ABOUT THE AUTHORS

Emily Hamilton is the policy research manager for the State and Local Policy Project at the Mercatus Center at George Mason University. Her writing has appeared in *USA Today*, the *Christian Science Monitor*, *Economic Affairs*, and the *Philadelphia Inquirer*. She contributes to the blog *Market Urbanism*.

Hamilton is an alumna of the Mercatus Center's MA Fellowship at George Mason University. After completing her MA, she worked in commercial real estate market research before returning to the Mercatus Center as an associate director of state outreach. She is currently a PhD student in economics at George Mason University.

Eli Dourado is a former senior research fellow at the Mercatus Center at George Mason University. He has studied and written about a wide range of technology policy issues, including internet governance, intellectual property, cybersecurity, and cryptocurrency. His focus was on aviation innovation—commercial drones, supersonic flight, and flying cars. His popular writing has appeared in the *New York Times*, the *Wall Street Journal*, the *Washington Post*, and *Foreign Policy*, among other outlets.

Dourado was an adviser to the State Department on international telecommunication matters and has served on several US delegations to UN treaty and policy conferences. He received a PhD in economics from George Mason University and a BA in economics and political science from Furman University.

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