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County Walkability and Small Business Receipts

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COUNTY WALKABILITY AND SMALL BUSINESS RECEIPTS

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ABSTRACT

This thesis explores the correlation between county walkability and small business receipts, as well as other possible demographic variables that could explain the success of small businesses, by using a fixed-effect panel regression model. Using county-level data in the years 2012 and 2017, this paper finds that there is a significant correlation between an increase in walkability and an increase in receipts. When running the fixed-effect regressions, this paper found that there is a moderately high positive correlation between walkability and per capita income, suggesting that the effects of an increase in walkability may also capture the effects of an increase in income. Thus, this paper ran a second set of regressions, finding without controlling for the effects of changes in income, a change in walkability is highly significant when it comes to changes in receipts. After interpreting the results, this paper recommends that a government that is concerned about the state of the economy, and more specifically the success of small businesses, should focus on urban policy that will work to improve walkability.

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Introduction

This paper is intended to answer the following research questions: Does an increase in county walkability have a significant and positive correlation to an increase in small business receipts? Why should this possible relationship be addressed?

Over the past several decades, there has been an increasing desire to live in walkable cities. As a result, movements calling for the redesign of cities to them more walkable, like StrongTowns,[1] have become ever more visible and vocal. Small businesses have long been considered the backbone of the American economy. Repeatedly, research has found that small businesses create a significant share of new jobs and provide many opportunities for women and members of minority groups.[2] Yet, it is frequently assumed that additional federal and state regulations, particularly regulations intended to protect the environment, disproportionately affect small businesses.[3] Even though studies, like Becker et al. (2013),[4] have found that these sentiments are not always supported by evidence, the aversion to environmental regulation is relevant to policymakers. The relationship between walkability and small business receipts is then of particular interest, as walkability has the potential to be a unique tool to simultaneously prioritize the wellbeing of the environment and small businesses.

To analyze this relationship, it is first necessary to define walkability, in a context in which there is not a singular agreed-upon definition. The nuances of walkability are discussed

[1] "Strong Towns," Strong Towns, https://www.strongtowns.org.
[2] David Neumark, Brandon Wall, and Junfu Zhang, "DO SMALL BUSINESSES CREATE MORE JOBS? NEW EVIDENCE FOR THE UNITED STATES FROM THE NATIONAL ESTABLISHMENT TIME SERIES," *THE REVIEW OF ECONOMICS AND STATISTICS*, n.d., 14.
[3] "The Impact of Regulatory Costs on Small Firms | The U.S. Small Business Administration | SBA.Gov," https://www.sba.gov/advocacy/impact-regulatory-costs-small-firms.
[4] Randy A. Becker, Carl Pasurka, and Ronald J. Shadbegian, "Do Environmental Regulations Disproportionately Affect Small Businesses? Evidence from the Pollution Abatement Costs and Expenditures Survey," *Journal of Environmental Economics and Management* 66, no. 3 (November 2013): 523–38, https://doi.org/10.1016/j.jeem.2013.08.001.

later in this paper. However, to define walkability a simple definition provided by Fan et al. (2017) is used, which states that walkability is the "extent to which walking is readily available as a safe, connected, accessible, and pleasant mode of transport".[5] Another term that is often included in measurements of walkability is active transportation, which refers to the use of public transportation, walking, and biking. This paper focuses on walkability but also considers the degree to which biking and public transit are supported by infrastructure. After providing a definition, a walkability index for each United States county in both 2012 and 2017 is created. The variables included are based on previous literature on walkability, discussed in more detail in the literature review and data sections of this thesis. Using this index, and a set of control variables (per capita income, percent of the population that consists of people of color (POC), percent female, percent Democratic, and median age), this study runs a fixed-effects regression to determine the direction and statistical significance of this relationship. As will be discussed in the results section, an increase in walkability is found to have a positive correlation to an increase in small business receipts.

Background and Literature Review

In 1987, the World Commission on Environment and Development published *Our Common Future* (later known as the Brundtland Report). One of the significant concepts discussed in this report is sustainable development and its appropriate definition. The report explains that sustainable development is growth that "meets the needs of the present without compromising the ability of future generations to meet their own needs".[6] This rather vague

[5] Peilei Fan et al., "Walkability in Urban Landscapes: A Comparative Study of Four Large Cities in China," *Landscape Ecology* 33, no. 2 (February 2018): 323–40, https://doi.org/10.1007/s10980-017-0602-z.
[6] Federal Office for Spatial Development ARE, "1987: Brundtland Report," https://www.are.admin.ch/are/en/home/nachhaltige-entwicklung/internationale-zusammenarbeit/agenda-2030-fuer-nachhaltige-entwicklung/uno-_-meilensteine-zur-nachhaltigen-entwicklung/1987--brundtland-bericht.html.

definition has spawned a multitude of environmental movements, each with its own understanding of the goal and practices to attain it. Two such movements, Smart Growth and New Urbanism, have gained momentum and validity in the United States, as they incorporate sustainability into urban development. Smart Growth advocates for land-use controls and regional/local policies to restrain urban sprawl to achieve more compact development, urban revitalization, and transportation diversity, among other things. New Urbanism differs from Smart Growth by focusing primarily on architecture. New Urbanism works to improve quality of life by increasing the presence of compact, mixed-use, and pedestrian-oriented development/infrastructure.[7] While these two movements have different orientations, they both seek to increase the accessibility of non-automobile transport modes (walking, biking, and public transit) in order to mitigate the negative effects of urban sprawl.[8]

The built environment, the manufactured infrastructure used to support human activity, is necessarily linked to travel behavior. Ewing and Cervero (2010) expand concepts outlined in earlier literature to explain how the built environment can impact travel modes via the "fives Ds": density, diversity, design, destination accessibility, and distance to transit.[9] Net residential density and employment density are the two most commonly used variables to capture an area's density. Areas that have higher densities are typically more walkable.[10] Diversity refers to the

[7] Edward J. Jepson and Mary M. Edwards, "How Possible Is Sustainable Urban Development? An Analysis of Planners' Perceptions about New Urbanism, Smart Growth and the Ecological City," *Planning Practice & Research* 25, no. 4 (August 1, 2010): 417–37, https://doi.org/10.1080/02697459.2010.511016.
[8] James A. Kushner, "Smart Growth, New Urbanism and Diversity: Progressive Planning Movements in America and Their Impact on Poor and Minority Ethnic Populations," *UCLA Journal of Environmental Law and Policy* 21, no. 1 (2002), https://doi.org/10.5070/L5211019395.
[9] Reid Ewing and Robert Cervero, "Travel and the Built Environment," *Journal of the American Planning Association* 76, no. 3 (June 21, 2010): 265–94, https://doi.org/10.1080/01944361003766766.
[10] Eva Leslie et al., "Walkability of Local Communities: Using Geographic Information Systems to Objectively Eva Leslie et al., "Walkability of Local Communities: Using Geographic Information Systems to Objectively Assess Relevant Environmental Attributes," *Health & Place* 13, no. 1 (March 2007): 111–22, https://doi.org/10.1016/j.healthplace.2005.11.001.

mix of land use; as an area incorporates more classes of land use (residential, commercial, industrial, and recreational), it is considered to be more "mixed" and better suited to address greater needs.[11] Design refers to street network characteristics, typically measured by average block size, number of intersections per square mile, and street connectivity. Areas that have a variety of potential destinations that can be reached via a direct pathway are considered to be more walkable than those that lack land use mix and street connectivity.[12] Destination accessibility measures the number of people that can reach a destination within a given travel time. Distance to transit is measured as the average of the shortest street routes from the home or workplace to the nearest public transit stop. These five dimensions of walkability are frequently cited by other authors as they create their own variations of walkability indices.

Freeman et al. (2012) conducted a study in New York City to determine whether an increase in walkability resulted in an increase in episodes of active travel. The authors created their walkability index using data from the 2000 census on residential and intersection density, land use mix for 5 types of land (residential, office, retail, education, and entertainment), subway stop density, and the ratio of retail building floor area to retail land area. A one-unit increase in this index resulted in a 10% decrease in the probability of residents reporting zero episodes of active travel.[13] Liao et al. (2020) similarly found that people who lived in highly walkable neighborhoods

[11] Brian E. Saelens, James F. Sallis, and Lawrence D. Frank, "Environmental Correlates of Walking and Cycling: Findings from the Transportation, Urban Design, and Planning Literatures," *Annals of Behavioral Medicine: A Publication of the Society of Behavioral Medicine* 25, no. 2 (2003): 80–91, https://doi.org/10.1207/S15324796ABM2502_03.
[12] Lawrence D. Frank et al., "Linking Objectively Measured Physical Activity with Objectively Measured Urban Form: Findings from SMARTRAQ," *American Journal of Preventive Medicine* 28, no. 2 Suppl 2 (February 2005): 117–25, https://doi.org/10.1016/j.amepre.2004.11.001.
[13] Lance Freeman et al., "Neighborhood Walkability and Active Travel (Walking and Cycling) in New York City," *Journal of Urban Health: Bulletin of the New York Academy of Medicine* 90, no. 4 (August 2013): 575–85, https://doi.org/10.1007/s11524-012-9758-7.

were more likely to choose to walk to destinations regardless of distance.[14] These findings make a crucial point for sustainable development: If urban design and policies focus on developing or improving elements that increase an area's measured walkability, changes in travel behavior will generally follow. However, this travel behavior changes with different socio-economic characteristics. People of color (Black, Hispanic, and Asian), the elderly, and people with lower education levels are less likely to utilize walking or biking as a method of transportation.[15]

Frank et al. (2006) conducted a study in King County, Washington, to determine the impact walkability had on air quality. They found that a 5% increase in walkability resulted in a 6.5% decrease in per capita vehicle miles of travel (VMT), a 5.6% decrease in grams of NOx emitted per capita, and a 5.5% decrease in grams of Volatile Organic Compounds (VOC) emitted per capita. This means that residents of walkable neighborhoods drove less and produced less air pollution than people who live in less walkable neighborhoods, creating an overall healthier environment.[16]

Walkability has a positive impact on two kinds of health: physical and mental. Frank et al. (2005) found that people living in walkable areas were more likely to achieve or exceed the recommendation of 30 minutes of physical activity per day.[17] Although human health is more nuanced than the number of minutes spent moving, a large body of literature has identified sedentary behavior as a major risk factor for chronic disease.[18] According to Leslie and Cerin

[14] Bojing Liao et al., "How Does Walkability Change Behavior? A Comparison between Different Age Groups in the Netherlands," *International Journal of Environmental Research and Public Health* 17, no. 2 (January 15, 2020): E540, https://doi.org/10.3390/ijerph17020540.
[15] Freeman et al. (2013).
[16] Lawrence D. Frank et al., "Many Pathways from Land Use to Health: Associations between Neighborhood Walkability and Active Transportation, Body Mass Index, and Air Quality," *Journal of the American Planning Association* 72, no. 1 (March 31, 2006): 75–87, https://doi.org/10.1080/01944360608976725.
[17] Frank et al. (2005).
[18] Mark Hamer, "Physical Activity and Health: MMXII," *Journal of Epidemiology and Community Health* 66, no. 8 (August 2012): 665–66, https://doi.org/10.1136/jech-2012-201589.

(2008), perceptions of built environment characteristics can influence residents' level of satisfaction with living in a certain community, and this satisfaction can impact mental health. Increased infrastructure for walking, aesthetics, traffic safety, social networking, and street connectivity also reduced negative mental health aspects like stress, depression, and anxiety.[19]

Another benefit of a walkable urban design is that it fosters a sense of community and generates social capital. The Organization for Economic Co-operation and Development (OECD) defines social capital as "networks together with shared norms, values, and understandings that facilitate cooperation within or among groups".[20] Leyden (2003) found that pedestrian-oriented and mixed-use neighborhoods increase social capital by enabling residents to interact, both intentionally and spontaneously. His study revealed that, in walkable neighborhoods, residents were more likely to know, trust, and interact with their neighbors.[21] Rogers et al. (2012) observed that, by creating a third place, outside the home and work, walkability provides means and locations for individuals to interact, thereby increasing social capital. The exhibited increase in neighborhood social capital also played a role in improving quality of life by, among other things, limiting isolation, improving career networking opportunities, and reducing crime.[22]

Walkability thus seems to have a variety of benefits for a community. But how can its economic value be examined (or measured)? One measure is property value. As an area's

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[19] Eva Leslie and Ester Cerin, "Are Perceptions of the Local Environment Related to Neighbourhood Satisfaction and Mental Health in Adults?," *Preventive Medicine* 47, no. 3 (September 2008): 273–78, https://doi.org/10.1016/j.ypmed.2008.01.014.

[20] "OECD Glossary of Statistical Terms - Social Capital Definition," https://stats.oecd.org/glossary/detail.asp?ID=3560..

[21] Kevin M. Leyden, "Social Capital and the Built Environment: The Importance of Walkable Neighborhoods," *American Journal of Public Health* 93, no. 9 (September 2003): 1546–51.

[22] Shannon H. Rogers et al., "Examining Walkability and Social Capital as Indicators of Quality of Life at the Municipal and Neighborhood Scales," *Applied Research in Quality of Life* 6, no. 2 (June 1, 2011): 201–13, https://doi.org/10.1007/s11482-010-9132-4.

walkability increases, the value of any office, retail, or apartment property increases as well.[23] Not only does walkability increase property value, but it has also been shown to protect housing prices during periods of housing market downturn.[24] For consumers, walkability generates savings in transportation costs. That, in turn, typically has another economic benefit: Consumers often shift expenditures once spent on vehicle transportation to other consumer goods. This shift can stimulate the local/regional economy.[25]

Using the metro areas of Phoenix and Boston, Credit and Mack (2019) examine whether built environment characteristics associated with walkability improved business performance, measured through the volume of employee sales.[26] Mixed land use, an aggregate of employment and residential density, block length, and accessibility for transit and pedestrian/bike users were the most important built environment characteristics for predicting business performance. When controlling for the effects of industry (retail, knowledge, and manufacturing), neighborhood walkability explained a significant portion of the variation in sales per employee. The study's key finding was that some features of walkable built environments are positively associated with business performance but that this association varies significantly depending on the business industry and the city that is being examined. This study, in conjunction with Litman's (2003) predicted consumer benefits, sets a precedent for examining the effects walkable built environments might have on business performance.

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[23] Gary Pivo and Jeffrey D. Fisher, "The Walkability Premium in Commercial Real Estate Investments," *Real Estate Economics* 39, no. 2 (2011): 185–219, https://doi.org/10.1111/j.1540-6229.2010.00296.x.
[24] Minjie Xu et al., "Single-Family Housing Value Resilience of Walkable Versus Unwalkable Neighborhoods During a Market Downturn: Causal Evidence and Policy Implications," *American Journal of Health Promotion: AJHP* 32, no. 8 (November 2018): 1714–22, https://doi.org/10.1177/0890117118768765.
[25] Todd Alexander Litman, "Economic Value of Walkability," *Transportation Research Record* 1828, no. 1 (January 1, 2003): 3–11, https://doi.org/10.3141/1828-01.
[26] Kevin Credit and Elizabeth Mack, "Place-Making and Performance: The Impact of Walkable Built Environments on Business Performance in Phoenix and Boston," *Environment & Planning B* 46 (May 3, 2017), https://doi.org/10.1177/2399808317710466.

Hamidi and Zandiatashbar (2019) conducted a study to determine the impact that compact and walkable development has on small knowledge-based firms. They found that walkable areas were more attractive to knowledge-based firms, due to their heightened social capital, which leads to increased knowledge spillover. These areas are also more desirable because they are more attractive to firm employees, due to enhanced destination accessibility. Nonetheless, the authors found an inverse/negative relationship between walkability and the number of small businesses when looking at the census tract database. This outcome is explained by the tendency for walkability to increase property values, potentially making these areas unaffordable for small businesses.[27] While this study sheds light on the potential benefits of a walkable built environment for the presence of businesses in a community, it does not consider walkability's impact on their performance. Combining methods and concepts used in Hamidi (2019) and Credit (2019), this thesis will examine the effect walkable built environments have on the performance of all small businesses in a given county.

Implicit in the research question is the assumption that walkability may have a particularly strong impact on small business receipts. Mehta (2011) explains how/why small businesses stand out, in comparison to larger businesses, in maintaining the vitality of the Main Street and its interactions with pedestrians.[28] People largely preferred small stores to large enterprises, not just because of the quality and range of goods and services available, but also because of their uniqueness, overall appearance, ambiance, and function as a community gathering spot. The way that small businesses offer goods/services and the in-store ambiance

[27] Shima Hamidi and Ahoura Zandiatashbar, "Does Urban Form Matter for Innovation Productivity? A National Multi-Level Study of the Association between Neighbourhood Innovation Capacity and Urban Sprawl," *Urban Studies* 56, no. 8 (June 1, 2019): 1576–94, https://doi.org/10.1177/0042098018767002.
[28] Vikas Mehta, "SMALL BUSINESSES AND THE VITALITY OF MAIN STREET," *Journal of Architectural and Planning Research* 28, no. 4 (2011): 271–91.

they developed meant that these businesses were creating an experience for the customer that could not be easily replicated at a large or chain store. Small stores also tended to require less space/street frontage, allowing streets to have a greater diversity of businesses. This created room for increased customer engagement. Finally, customers who frequently visited the Main Street knew the people who owned or worked at the small businesses. These social relationships increased the chances of customers lingering and window shopping, which encouraged more purchases. The work done by Mehta validates the assumption that small businesses may uniquely benefit from an increase in walkability.

Theory

Location and Agglomeration

In this paper, walkability captures the proximity of stores to customers and to other stores. We would expect businesses, small businesses, in particular, to benefit from proximity and accessibility to potential customers. This can be understood through the examination of the consumer budget constraint. A consumer decides to buy a good or service based on the cost of the good and this purchase is restricted by the consumer's discretionary income (money left after paying taxes and necessities like rent, utilities, and groceries). The consumer budget constraint model and theory state that consumption is influenced by changes in [discretionary] income and product prices. If discretionary income were to incorporate transportation costs (that is discretionary income is money left after taxes, rent, utilities, and transportation), then it becomes clear why walkability would benefit businesses. As walkability increases, consumer transportation costs decrease, leaving consumers with more discretionary income that can be used on non-essential goods and services. This relationship is depicted in the equation below,

where X represents a small business good/service and Y represents a large business good/service:

$$Discretionary\ Income = P_X X + P_Y Y$$

This increase in available money can benefit small businesses for two reasons: For small businesses that offer goods and/or services at prices comparable to their larger counterparts, consumers will be able to purchase more goods than before. For small businesses that offer their goods and/or services at higher prices than their larger competitors (but with other benefits, such as more personal services and a more comfortable setting), the increase in spendable money increases the feasibility of purchase. Consumers who were once deterred from the transaction due to a budget constraint are now able to engage and consume products from small businesses.

Small businesses might also benefit from walkability between their store and another store, also known as agglomeration of stores. Agglomeration brings benefits as firms have increased access to shared knowledge and a large labor pool. Stores that are in a close and walkable proximity to each other also have the potential to create demand externalities, in which consumers are able to make unplanned visits and purchases at neighboring stores.[29] This agglomeration creates the potential for stores to attract a new or unexcepted consumer base, which would be beneficial to all types and sizes of businesses. Using the findings from Mehta (2011),[30] we might expect this benefit to be magnified for small businesses due to the heightened engagement, personalization, and friendliness that are typically associated with small businesses and their street frontage. That is, although walkability should generate a new potential consumer

[29] Andres Sevtsuk, "Location and Agglomeration: The Distribution of Retail and Food Businesses in Dense Urban Environments," *Journal of Planning Education and Research* 34, no. 4 (December 1, 2014): 374–93, https://doi.org/10.1177/0739456X14550401.
[30] Mehta (2011).

base for all types and sizes of businesses, small businesses might be more successful in capturing additional purchases from new customers. Eaton and Lipsey (1979) amended Hotelling's location model (1929) to describe the benefit a customer would derive from the clustering of homogenous stores.[31] They explained that, in the presence of comparison shopping (comparing the product and/or its price between two or more stores), a consumer would benefit from the clustering of homogenous stores, as it would minimize their search and transportation cost. That, in turn, makes it more likely that the purchasing dollars at a given store will increase and stay in the local area, benefiting the community and its collection of businesses as a whole.

Social Capital Theory

Social capital can be understood as a concept that includes the commitment of citizens to act inside their own community and reciprocity among the members of a particular community.[32] As interactions between members of a community increase, the level of civic commitment and social integration also increases. Yildiz et al. (2017) uses social capital theory to explain why individuals might choose to shop at a small/local business. They found that the more civic acts an individual performs, the more committed he/she/they are to the community and the more likely that individual is to shop at small local businesses. As their civic activity increases, their loyalty to their community and local retailers strengthens. Individuals are then more likely to shop at these stores as a form of solidarity. Yildiz et al. also found that local shopping, in the name of loyalty, is reinforced by the consumers' own perception of their civic commitment. In

[31] B. Curtis Eaton and Richard G. Lipsey, "Comparison Shopping and the Clustering of Homogeneous Firms*," *Journal of Regional Science* 19, no. 4 (1979): 421–35, https://doi.org/10.1111/j.1467-9787.1979.tb00610.x.
[32] Hélène Yildiz, Sandrine Heitz-Spahn, and Lydie Belaud, "Explaining Small-Retailer Patronage through Social Capital Theory," *International Journal of Retail & Distribution Management* 45, no. 6 (January 1, 2017): 641–59, https://doi.org/10.1108/IJRDM-11-2015-0173.

other words, as the consumer's perception of their civic commitment increases, the desire to shop locally increases as well.

Simultaneous Effects from Agglomeration and Social Capital

Businesses may benefit from high walkability as the dynamics of spatial proximity/agglomeration and social capital interact to increase innovation capacity. Walkability increases an area's social capital as it allows for more frequent social and cultural exchange, which produces informal networking opportunities as well as knowledge spillover. Walkability also enhances accessibility and proximity between businesses (and their customers), which increases industry interactions, collaborations, and knowledge spillover. The ability to reap the benefits from agglomeration is magnified as social capital increases. Together, agglomeration and social capital act to increase the innovation capacity of firms.[33]

Data

To examine the relationship between walkability and small business receipts, this paper primarily uses data from the American Community Survey (ACS) and the Statistics of U.S. Businesses (SUSB). From the SUSB database, receipts (measured in $1,000) were measured for U.S. counties in 2012 and 2017. Business receipts, as defined by the Census Bureau, are "the operating revenue for goods produced or distributed, or for services provided".[34] In these datasets, there were five classifications of businesses, based on employment size.[35] A business can be considered small based on its establishment size or its sales/revenue size. This paper applies one of the definitions provided by the Census Bureau, [36] which describes a small business

[33] Hamidi and Zandiatashbar (2019).
[34] US Census Bureau, "Glossary," Census.gov, https://www.census.gov/programs-surveys/susb/about/glossary.html.
[35] (1) All businesses in a county (2) <20 employees (3) 20-99 employees (4) 100-499 employees (5) 500+ employees
[36] US Census Bureau, "What Is a Small Business?," Census.gov, https://www.census.gov/library/stories/2021/01/what-is-a-small-business.html.

as an establishment with an employment size of fewer than 20 employees. This working definition reflects businesses that employ less than 25% of the workforce, regardless of industry.

The independent and dependent variables examined in this study are summarized below:

Table 1

Definition for Variables

Variables	**Definition**
Dependent Variable	--
ReceiptsperEstablishment	Receipts per establishment measured in $1000
Independent Variable	--
WalkIndex	A measure of walkability created in this paper
EmployHouseMix	Diversity of Employment and Residential Activity
EmployMix	Diversity of Employment Activity
WalkandBikeCommute	Percentage of the population that walked or biked to work
PercentTransCommute	Percent of the population that used public transportation to get to work
MotorCrash	Vehicle crash mortality rate per 100,000 population
PopDen	Population Density Per Square Mile
Controlled Variable	--
PerCapitaIncome	The amount of money earned per person in a given county
PercentPOC	The percent of the population that is a person of color
MedianAge	The median age of the population
PercentDemocrat	The percent of individuals that voted for the Democratic Party candidate y in the most recent presidential election (2012 and 2016)
PercentFemale	The percentage of the overall population that is female

Walkability Index

The Smart Location Database (SLD), created by the Environmental Protection Agency (EPA), is a nationwide dataset containing measurements for demographic, employment, and built

environment variables.[37] The SLD has created a database that contains variables to capture the five D's of walkability, a concept created by Ewing and Cervero (2010): population density, land-use diversity, urban design, transit accessibility, and destination accessibility.[38] The SLD then constructed a walkability index based on four variables: 5-tier employment and house entropy, 8-tier employment entropy, street intersection density, and distance to the nearest transit stop. While EPA has created a credible walkability index, the index could not be used in this paper because it does not include observations for varying years. Since this paper seeks to examine the correlation between a change in walkability and a change in small business receipts, the walkability index must be observable for at least two years. This paper does, however, use the SLD as a guide for the creation of a new walkability index. Another issue that was experienced when working with the SLD and trying to create a similar index for 2012 was one of feasibility. For some of the variables of walkability, like street intersection density and distance to the nearest transit stop, the collection of data was not possible.[39] As a result, the walkability index generated in this study makes use of proxies, calling upon previous literature for guidance. The WalkIndex presented here consists of six individual variables: PercentEmpHouseMix, PercentEmpMix, PercentTransCommute, WalkandBikeCommute, MotorCrash, and PopDen.

PercentEmpHouseMix and PercentEmpMix are two variables that measure a county's land-use diversity. Land-use diversity measures the evenness of distribution of square footage of residential, commercial, and office development. An area with a high diversity indicates a greater degree of easily accessible destinations, making the area more walkable.[40] These variables were

[37] James Chapman et al., "Smart Location Database Technical Documentation and User Guide Version 3.0," *Environmental Protection Agency*, n.d., 55.
[38] Ewing and Cervero (2010).
[39] Existing datasets were not free and therefore not usable in the context of this thesis
[40] Frank et al. (2005).

created following the methodology used by the EPA for their Smart Location Database. The ACS provides employment counts by industry for U.S. Counties, which are broken down into 13 NAICS classifications. Employment and household counts were also downloaded from the ACS. The PercentEmpHouseMix uses the 5-tier employment scale, while the PercentEmpMix uses a 7-tier employment scale. The specification for these tiers can be found in Appendix A. As such, PercentEmpHouseMix has a less fine-tuned focus on business diversity (using 5-tier rather than 7-tier) and accounts for the mix of housing units as well. Once the employment counts were regrouped to fit these two-tiered classifications, the formula, which can be found in Appendix B, was used to create the final variables (**Table 1**).

Walkability also considers the degree to which transportation methods are accessible. In lieu of the data used by the EPA to measure this, this study follows the method used by Credit and Mack (2019) in which methods of transportation to travel to work were used as a proxy for the extent to which an area has accessible walking, biking, and public transit infrastructure.[41] The use of this proxy is validated by the previously mentioned studies conducted by Freeman et al. (2012) and Liao et al. (2020). In their respective studies, both authors discovered that travel behavior and measured walkability are intrinsically linked. Therefore, greater use of public transit, walking, and biking as a means to get to work has the potential to accurately reflect the walkability of an area. The ACS provides percentages for within-county transportation modes for U.S. counties in the years 2012 and 2017.

Another aspect of walkability is pedestrian safety. Studies have found that the number of motor vehicle crashes directly influences the perception of safety for pedestrians and, therefore,

[41] Credit and Mack (2019).

acts as a key factor in transportation mode decisions.[42] There are characteristics of the built environment that can quell safety concerns (influencing perceptions of safety and comfort), and these same aspects can also increase the objective safety of an area.[43] To account for safety, this paper uses the vehicle crash mortality rate per 100,000 population (MotorCrash), from the U.S. Health Dataset,[44] as a proxy for a total crash count. The number of crashes is expected to have an inverse relationship with walkability: As the number of crashes increases, county walkability decreases.

The final walkability variable that is included is population density. This captures the overall spread of the population within a given county. This variable differs from PercentEmpHouseMix in that it uses population counts rather than housing unit counts. This variable, therefore, accounts for household size (the number of people living in one residential unit). As population density increases, walkability is expected to increase.

For all six sub-variables of walkability, an index was created in Stata. For the land-use, transportation, and population density variables (PercentEmpHouseMix, PercentEmpMix, PercentTransCommute, WalkandBikeCommute, and PopDen) observations that were above the 75th percentile received a rank of 4, indicating a higher walkability value. Observations between the 50th and 75th percentile received a rank of 3, and observations between the 25th percentile and 50th percentile received a 2. Any observations that were below the 25th percentile received a rank of 1, indicating lower walkability. An index was also created for the MotorCrash variable;

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[42] H M Abdul Aziz, "Exploring the Impact of Walk–Bike Infrastructure, Safety Perception, and Built-Environment on Active Transportation Mode Choice: A Random Parameter Model Using New York City Commuter Data," 2018, 23.
[43] Ahmed Osama et al., "Determining If Walkability and Bikeability Indices Reflect Pedestrian and Cyclist Safety," *Transportation Research Record* 2674, no. 9 (September 1, 2020): 767–75, https://doi.org/10.1177/0361198120931844.
[44] "Data Dictionary - Survey Health Data 2017 Release," Social Explorer, https://www.socialexplorer.com/data/HD2017.

however, observations that were above the 75th percentile received a rank of 1, as more crashes would make an area less walkable. After the individual indices were created, the overall walkability index was generated by taking the average of these six indices for each county in 2012 and 2017. The formula used to create the overall walkability index is:

$$WalkIndex = \frac{Land\ Use\ Index + Transportation\ Index + PedestrianSafetyIndex + PopDensityIndex}{4}$$

Where: $Land\ Use\ Index = \frac{EmployHouseMixIndex + EmployMixIndex}{2}$

$$Transportation\ Index = \frac{PublicTransitIndex + WalkandBikeIndex}{2}$$

As can be seen above, EmployHouseMixIndex and EmployMixIndex were averaged to create the Land Use Index. This was done because both indices measure a county's land use diversity. If these indices were not averaged to create a new index, the role of land use diversity would be exaggerated (as it would be accounted for twice in the overall WalkIndex). Similarly, the PublicTransitIndex and WalkandBikeIndex were also averaged to create the Transportation Index, for the same reason.

Control Variables

The first control variable is per capita income. This is hypothesized to positively influence small businesses receipts, as elevated income provides the means needed to enable more individuals to shop at small businesses, where the price for goods/services tends to be higher.[45] The next variable is the percentage of the population that is persons of color (PercentPOC). Previous literature has found that increasing racial diversity facilitates greater social and cultural exchange, which improves the innovative capacity of local firms, thereby

[45] Sejin Ha et al., "Consumer Sustainable Shopping Practices for Small Business during COVID-19," *Sustainability* 13, no. 22 (January 2021): 12451, https://doi.org/10.3390/su132212451.

boosting their consumer attraction and ability to survive.[46] For this reason, it is hypothesized that the percentage of POC in a county will positively influence receipts. Previous studies have also found that younger generations (Millennial and Gen X) are more likely to shop at a small business than the older Baby Boomer generation.[47] At the same time, young people, namely children and teenagers, are not the household shopping decision-makers and do not always have the economic freedom to choose where they shop or how much money they spend. Therefore, a higher median age is expected to result in an increase in small business receipts, but this increase is not exponential (there is a point at which an older population would be correlated with a decrease in business receipts). The significance of the role that gender might play in influencing small business success is unclear. Ha et al. (2021) found that women were more likely to shop at small businesses, but, when run in a regression, this difference was not statistically significant. Edirisinghe et al. (2020), on the other hand, found there was a notable difference in shopping behaviors between men and women, leading to a higher frequency of small business loyalty among women in comparison to men. Thus, PercentPopFemale is expected to have a positive relationship with receipts, but this relationship may not be significant. The data for these four control variables come from the ACS 2012 1-year and ACS 2017 1-year estimate datasets. The final control variable is the percent of the population that voted for the Democratic Party candidate in the two elections proximate to the two years in which this study's data are available (2012 and 2016 presidential elections). While there is not abundant literature discussing the link between political affiliation and small business receipts, it is an interesting factor to consider and control for. Data for political affiliation came from the MIT Election Data and Science Lab.[48]

[46] Hamidi and Zandiatashbar (2019).
[47] Sejin Ha et al. (2021).
[48] MIT Election Data and Science Lab, "County Presidential Election Returns 2000-2020" (Harvard Dataverse, March 18, 2022), https://doi.org/10.7910/DVN/VOQCHQ.

The summary statistics for the variables can be found below, where observations are categorized by their corresponding rural-urban continuum code.[49] This code classifies every U.S. County based on its population size, with RUCC 1-3 representing metropolitan counties and RUCC 4-6 representing non-metropolitan counties. As can be seen in the table below, most U.S. counties included in this study fall within the metropolitan category. Because there were so many counties included in this study (332 for each year), it was not possible to include summary statistics for each individual county in a table, which is why the summary categorization of the RUCC was used.

Table 2
Summary Statistics (Mean and Standard Deviation) Based on RUCC

RUCC	**1 (N=328)**		**2 (N=240)**		**3 (N=84)**		**4 (N=8)**		**5 (N=6)**	
Variable	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
ReceiptsperEstablishment	821.91	152.97	735.48	138.85	701.11	121.61	672.89	89.36	606.57	66.09
WalkIndex	2.90	0.55	2.40	.54	2.12	0.49	1.44	.086	2.39	0.14
PerCapitaIncome	34694	8953	28735	5682	27566	5026	24348	3057	27641	4171
PercentPOC	30.09	15.85	22.57	13.20	16.61	10.99	11.61	12.28	30.32	28.84
MedianAge	38.03	3.18	37.32	4.49	37.36	5.84	40.09	4.33	37.85	4.02
PercentPopFemale	50.93	0.8971	50.77	0.9172	50.25	1.59	50.60	0.4865	49.48	0.8678
PercentDemocrat	55.35	14.33	49.35	12.12	43.75	12.65	37.19	5.89	57.50	11.16

Model

This study uses the fixed-effect regression model to evaluate the correlation between walkability and small business receipts for various U.S. counties in 2012 and 2017. Before running the appropriate regressions, the correlation between all the independent variables was

[49] "USDA ERS - Rural-Urban Continuum Codes," https://www.ers.usda.gov/data-products/rural-urban-continuum-codes.aspx.

checked. This revealed that both PerCapitaIncome and PercentDemocrat were highly correlated with the WalkIndex variable **(Appendix C)**. This means that there is a relationship between walkability and income, as well as walkability and Democratic Party affiliation. As was previously discussed, there is a connection between walkability and economic well-being, which is a possible explanation for the detected correlation between walkability and income.[50] The correlation between walkability and Democratic party affiliation suggests that areas that are highly walkable tend to be more democratic. Because of these correlations, the explanatory power of the walkability index is weakened. PercentDemocrat was also highly correlated with PercentPOC, which suggests that counties with higher racial diversity are more likely to vote for the Democratic candidate and vice versa. To avoid any potential omitted variable bias, this paper runs two different regression equations, one that included PerCapitaIncome and PercentDemocrat, and one that does not. The general regression equations that were utilized are illustrated below:

(a) $ReceiptsperEstablishment_{it} = \beta_0 + \beta_1 WalkIndex_{it} + \beta_2 PerCapitaIncome_{it} + \beta_3 PercentPOC_{it} + \beta_4 MedianAge_{it} + \beta_5 PercentPopFemale_{it} + \beta_6 PercentDemocrat_{it} + \varepsilon_{it}$

(b) $ReceiptsperEstablishment_{it} = \beta_0 + \beta_1 WalkIndex_{it} + \beta_2 PercentPOC_{it} + \beta_3 MedianAge_{it} + \beta_4 PercentPopFemale_{it} + \varepsilon_{it}$

This study also individually tests the six variables used to create the walkability index. When the individual variables are tested, the raw data (instead of the index that was created) is used. With the regression equations found below, X_{it} represents the set of control variables:

[50] Todd Alexander Litman (2003).

(I) $ReceiptsperEstablishment_{it} = \beta_0 + \beta_1 PercentEmpHouseMix_{it} + \beta X_{it} + \varepsilon_{it}$

(II) $ReceiptsperEstablishment_{it} = \beta_0 + \beta_1 PercentEmpMix_{it} + \beta X_{it} + \varepsilon_{it}$

(III) $ReceiptsperEstablishment_{it} = \beta_0 + \beta_1 PercentTransCommute_{it} + \beta X_{it} + \varepsilon_{it}$

(IV) $ReceiptsperEstablishment_{it} = \beta_0 + \beta_1 WalkandBikeCommute_{it} + \beta X_{it} + \varepsilon_{it}$

(V) $ReceiptsperEstablishment_{it} = \beta_0 + \beta_1 MotorCrash_{it} + \beta X_{it} + \varepsilon_{it}$

(VI) $ReceiptsperEstablishment_{it} = \beta_0 + \beta_1 PopDen_{it} + \beta X_{it} + \varepsilon_{it}$

This thesis runs two additional regressions, using Equation B, but separates counties based on their RUCC classification:

Metro: $ReceiptsperEstablishment_{it} = \beta_0 + \beta_1 WalkIndex_{it} + \beta_2 PercentPOC_{it} + \beta_3 MedianAge_{it} + \beta_4 PercentPopFemale_{it} + \varepsilon_{it}$, if RUCC ≤ 3

Rural: $ReceiptsperEstablishment_{it} = \beta_0 + \beta_1 WalkIndex_{it} + \beta_2 PercentPOC_{it} + \beta_3 MedianAge_{it} + \beta_4 PercentPopFemale_{it} + \varepsilon_{it}$, if RUCC ≥ 4

In the following results section, there are 16 different regression equations, which are organized into three different tables.

Results and Analysis

When all control variables are included in the model, there is a significant positive correlation between walkability and establishment receipts, with a one-unit increase in walkability resulting in a $39,150 increase in small business receipts. That is to say, holding constant the effects a change in income, population age, race, gender identity, or political affiliation may have on small businesses, an increase in a county's walkability does significantly improve the success of small businesses. The regression results also indicate that an increase in a county's per capita income corresponds to a slight, but statistically significant, increase in

receipts. MedianAge is the final variable that is statistically significant, at the 10% level, in which a one-year increase in median age corresponds to a $13,680 increase in receipts (**Table 3a**).

Table 3a
Regression Results with All Control Variables

ReceiptsperEstablishment	I	II	III	IV	V	VI	VII
WalkIndex (I)	39.15 (21.14) *						
PercentEmpHouseMix (II)		4.539 (4.936)					
PercentEmpMix (II)			-2.678 (4.685)				
PercentTransCommute (IV)				-9.146 (6.006)			
WalkandBikeCommute (V)					-0.3379 (5.271)		
MotorCrash (VI)						-4.237 (2.328)*	
PopDen (VII)							0.00365(0.0241)
PerCapitaIncome	0.00674 (0.00151)***	0.00760 (0.00144) ***	0.00770 (0.00144) ***	0.00853 (0.00148) ***	0.00784 (0.00143) ***	0.00656 (0.00158) ***	0.00778 (0.00150) ***
PercentPOC	1.464 (1.901)	1.88(1.891)	1.683 (1.890)	1.832 (1.882)	1.753 (1.892)	1.646 (1.879)	1.754 (1.889)
MedianAge	13.68 (7.371) *	13.37 (7.260) *	14.02 (7.232) *	11.91 (7.342)	14.01 (7.237) *	8.829 (7.743)	14.03 (7.235) *
PercentPopFemale	3.493 (11.99)	5.575 (11.84)	6.160 (11.84)	4.732 (11.83)	6.042 (11.85)	2.492 (11.94)	6.152 (11.88)
PercentDemocrat	-1.745 (1.327)	-2.049 (1.277)	-2.054 (1.279)	-1.758 (1.291)	-2.07 (1.281)	-1.319 (1.338)	-2.115 (1.307)

Note: *** denotes statistical significance at the 1% level, ** denotes statistical significance at the 5% level, and * denotes statistical significance at the 10% level. Results without an asterisk are statistically insignificant.

After running the primary regression, which focused on the overall walkability, the individual variables that made up the walkability index were examined (specification II-VII). These regressions reveal that, on their own, only MotorCrash has a significant correlation to small business receipts. At the 10% significance level, the MotorCrash variable has a negative correlation to receipts, in which each additional motor crash fatality corresponds to a $4,237

decrease in receipts. Since a large MotorCrash variable indicates higher mortality, and therefore worsening pedestrian safety, it makes sense that it is negatively correlated to small business receipts. The fact that the other individual walkability variables are not statistically significant does not imply that they are not important in terms of walkability, but that, on their own, they do not have a significant impact on the success of small businesses.

From the results of the second regression model, presented in **Table 3b**, it is clear that, absent changes in PerCapitaIncome and PercentDemocrat, there is a highly significant positive correlation between an increase in walkability and an increase in small business receipts. A one-unit increase in walkability results in a $77,290 increase in small business receipts. The walkability coefficient is also greater in this regression than it was in **Table 3a**. One way to interpret this difference is that some changes in receipts that resulted from the increase in walkability were being attributed to PerCapitaIncome. Thus, removing the income variable increases the explanatory power of walkability, which is why the regression reflects increased changes as a result of a one unit change in walkability. There is also a significant and positive correlation between the PercentPOC and receipts, with a 1% increase in the POC share of the population resulting in a $4,166 increase in receipts. This relationship was anticipated, with a likely explanation for this relationship being that racial diversity increases the innovation capacity of small businesses, making them more likely to succeed in securing a larger customer base. As PercentDemocrat was removed from the regression equation, PercentPOC became significant, which is understandable since these two variables had a relatively high correlation.

Table 3b

Regression Results Excluding PerCapitaIncome and PercentDemocrat

ReceiptsperEstablishment	I	II	III	IV	V	VI	VII
WalkIndex (I)	77.29 (20.24) ***						
PercentEmpHouseMix (II)		10.33 (5.084)**					
PercentEmpMix (II)			-8.133 (4.837) *				
PercentTransCommute (IV)				-0.3349 (6.051)			
WalkandBikeCommute (V)					-6.183		
MotorCrash (VI)						-9.484 (1.982) ***	
PopDen (VII)							0.03543 (0.02374)
PercentPOC	4.166 (1.874) **	5.893 (1.850) ***	5.454 (1.871) ***	5.887 (1.879) ***	5.881 (1.859) ***	5.001 (1.840) **	5.665 (1.861) ***
MedianAge	34.50 (6.205)***	39.72 (6.041) ***	41.57 (5.888)***	43.13 (5.849)***	41.99 (5.920) ***	19.02 (7.564) **	41.62 (5.907) ***
PercentPopFemale	2.567 (11.55)	5.801 (11.64)	7.371 (11.64)	7.179 (11.70)	7.643 (11.68)	1.555 (11.36)	6.662 (11.66)

Note: *** denotes statistical significance at the 1% level, ** denotes statistical significance at the 5% level, and * denotes statistical significance at the 10% level. Results without an asterisk are statistically insignificant.

The MedianAge variable is once again significant, now at the 1% level, with a one-year increase in median age resulting in a $34,500 increase in receipts. After running this regression which tested the relationship between the overall walkability index and receipts, the individual variables making up the index were once again tested. This revealed that the 5-tier employment and residential diversity (PercentEmpHouseMix), as well as the 7-tier employment diversity (PercentEmpMix), are statistically significant. PercentEmpHouseMix has a positive correlation to receipts, with a 1% increase in diversity resulting in a $10,330 increase in receipts. This means that, as evenness and diversity of types of amenities mixed with housing, increases, so do small business receipts. The PercentEmpMix, unexpectedly, has a negative relationship with receipts, significant at the 10% level. A 1% increase in employment diversity (7-tier) resulted in an

$8,133 decrease in receipts. This suggests that, without accounting for the spread of residential units, having many different industries evenly spread across a county may not always benefit small businesses. The MotorCrash variable is once again significant, now at the 1% significance level, with a one-unit increase in crashes resulting in a $9,484 decrease in receipts. The percent of the population that identifies as female (PercentFemale) is the only variable that remained statistically insignificant across all variations of the walkability index (overall and individual measures). This result validates the finding from Ha et al. (2021), that while women do seem to shop at small businesses more frequently than men, this difference is not statistically significant.[51]

As seen in both tables of regression results, walkability does have a positive and significant correlation to small business receipts. The second table shows that removing the effects of a change in income results in increased explanatory significance of walkability.

Table 4

Regression Results for Various RUCC Classifications

ReceiptsperEstablishment	Metropolitan (RUCC ≤ 3)	Non-Metropolitan (RUCC ≥ 4)
WalkIndex	79.50 (20.43) ***	-306.3 (83.66)
PercentPOC	4.100(1.890) **	17.90 (7.225)
MedianAge	33.94 (6.364)***	49.40 (7.971)
PercentPopFemale	2.408 (11.65)	130.5 (41.42)

Note: *** denotes statistical significance at the 1% level, ** denotes statistical significance at the 5% level, and * denotes statistical significance at the 10% level. Results without an asterisk are statistically insignificant.

An additional set of regressions was run using equation B which does not account for changes in PerCapitaIncome or PercentDemocrat. This was done so that any changes in the correlation between walkability and receipts due to different urban classifications could be identified. When only including counties that are considered metropolitan (RUCC ≤ 3), the

[51] Ha et al. (2021)

walkability coefficient (79.50) is greater than it was when all counties were included (77.20; **Table 3b, Table 4**). In other words, the effect of a one-unit increase in the walkability index is greater when only urban counties are being examined. This finding agrees with conclusions made in Credit and Mack's (2019) analysis of walkability in Phoenix and Boston.[52] Areas that are considered rural generally have a more auto-centric urban form and may not experience the economic benefits of increased walkability as much as their metropolitan counterpart. Therefore, removing these rural counties from the regression is expected to enhance the observed relationship between walkability and receipts, in terms of coefficient size as well as significance (See **Appendix C, Stata 3 and 4**). Similar to the previous regressions, PercentPOC and MedianAge are significant and positively correlated with an increase in receipts, at the 5% and 1% levels, respectively. The regression for rural counties (RUCC $\geq$ 4) did not produce any statistically significant results (**Table 4**).

Policy Implications

The results from this study suggest there is statistical justification for economic policy that focuses on improving local walkability. By creating policy that improves pedestrian safety (via traffic speed regulations and improved crosswalks), diversity of amenities that are in close proximity to residential areas, and infrastructure that supports non-motorized transportation (accessible public transit stops, improved sidewalk conditions, and bike lanes), small businesses will likely see an increase in sales and related success. Not only would the economy benefit from this kind of policy, but society would see improvements in health, happiness, and community connectivity.

[52] Credit and Mack (2019).

This paper also adds to the previous study conducted by Hamidi and Zandiatashbar (2019),[53] in which they found that walkability can be beneficial for small businesses in terms of improved innovation capacity. They, however, concluded that walkable areas are unsustainable for small businesses due to the elevated property values and thus land rents associated with walkable areas. As previously stated, this study found that walkability can enhance the success and vitality of small businesses. Therefore, it is important for there to be policies that make it possible for small businesses to acquire land and meet the minimum rent requirements. In giving these opportunities, a local government may be able to support businesses by simply focusing on walkability rather than direct aid. Improved walkability continuously boosts small business success, rather than a one-time loan or direct aid. This means that policy focused on improving walkability can create sustained and self-fulfilling success for small businesses.

Limitations

This paper demonstrates the need for easily accessible data that can be used to quantify the walkability of any given area. The index created for this study was limited by feasibility, where most data related to aspects of walkability (like street connectivity, sidewalk conditions, relative distance to public transit, and relative distance to a set of destinations) were either nonexistent or expensive (financially and timewise). While it is possible to capture walkability through the use of proxies, to obtain the most accurate index, these data need to be public and accessible. With such data, it will be easier to justify the incorporation of walkability improvements into urban policy, as it becomes possible to highlight the main social and economic benefits associated with walkability.

[53] Hamidi and Zandiatashbar (2019).

Another limitation could be the lack of scope in terms of the years included in the data. This paper only examined walkability and business receipts in 2012 and 2017, because the Census Bureau only provides counts of said receipts for these years. Thus, future work could expand the scope and validity of the findings of this paper by obtaining data for more years.

Conclusion

This thesis addressed the relationship between county walkability and small business receipts. By compiling data on county land-use diversity, accessibility of public transit, walking, and biking transportation modes, pedestrian safety, and population density, this study successfully created a walkability index. Then controls for demographic variables (income, race, gender, and age) were created. Through the process of the regression analysis, the correlation between the walkability index and per capita income was detected, which led to the use of two regression equations, one including income and one excluding income. However, in both models, a significant, and positive, correlation between an increase in walkability and an increase in business receipts was identified. Then, policy implications for local government in regard to land-use planning that focuses on increased walkability were suggested, followed by an acknowledgment of study and data limitations.

Although this paper only examines walkability and small businesses in the years 2012 and 2017, the importance of both is ever more present today. The Coronavirus pandemic has changed society's relationship with the built environment and the accessibility to amenities that come from it. The implementation of stay-at-home orders revealed the importance of high walkability: convenience/accessibility of necessary goods and resilience capacity. Throughout the pandemic, we have seen an increased desire for accessible store locations and means of transportation. People want to be able to quickly walk to the store to get what they need.

Although there has been a reduction in the overall number of daily trips for both essential and non-essential goods, there has been a relative increase in the utilization of walking and biking to reach a destination. The use of these forms of transportation is expected to continue to grow following the end of the pandemic.[54] Not only has walkability been found to reduce transmission rates of COVID-19, but it also facilitated community activity despite restrictions on gathering.[55] Opportunities for social interaction and physical activity have helped individuals cope with high stress levels and remain healthy, both physically and mentally.[56] Areas with higher average walkability were thus better equipped to avoid COVID-19 infection and to cope with the collateral consequences of lockdown and stay-at-home orders. The pandemic has created the call for urban restructuring to create neighborhoods that are conducive to walking.

The pandemic has also affected gas prices by creating supply and demand issues. At the beginning of the pandemic, stay-at-home orders and business restrictions caused the demand for gas to fall. This decrease in demand was met with a reduction in production and supply. Following the mass roll-out of COVID-19 vaccinations, the United States began its return to "life as normal", which has been followed by a return to pre-pandemic gas demand. This increase in demand was not met with a concurrent increase in supply, leading to an increase in gas prices (and to inflation, in general).[57] In addition to this natural increase in gas demand

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[54] Md Mokhlesur Rahman et al., "Machine Learning on the COVID-19 Pandemic, Human Mobility and Air Quality: A Review," *IEEE Access: Practical Innovations, Open Solutions* 9 (2021): 72420–50, https://doi.org/10.1109/ACCESS.2021.3079121.

[55] Yucheng Wang et al., "Association of City-Level Walkability, Accessibility to Biking and Public Transportation and Socio-Economic Features with COVID-19 Infection in Massachusetts, USA: An Ecological Study," *Geospatial Health* 17, no. s1 (January 14, 2022), https://doi.org/10.4081/gh.2022.1017.

[56] Melissa L. Finucane et al., "Do Social Isolation and Neighborhood Walkability Influence Relationships between COVID-19 Experiences and Wellbeing in Predominantly Black Urban Areas?," *Landscape and Urban Planning* 217 (January 2022): 104264, https://doi.org/10.1016/j.landurbplan.2021.104264.

[57] "Gas Prices Rising as Stay-at-Home Orders Lift, but Could Stay Low for Months," *StateImpact Pennsylvania* (blog), May 12, 2020, https://stateimpact.npr.org/pennsylvania/2020/05/12/gas-prices-rising-as-stay-at-home-orders-lift-but-could-stay-low-for-months/.

following the most restrictive moments of the pandemic, Russia invaded Ukraine in February 2022, which was followed by a national ban on Russian imports of oil, natural gas, and coal.[58] Although the United States only gets about 8% of its oil from Russia, Russia is one of the largest oil exporters in the world, and the United States has felt the impact of the international decrease in supply and increase in gas prices. As gas prices continue to soar, with no end in sight, people have started to place a higher value on walkability: More individuals are unwilling, or unable, to pay the ever-higher gas prices.

The pandemic has not only highlighted the importance of walkability, but also the importance and vulnerability of small businesses. Despite their disproportionate contribution to the U.S. economy, small businesses have been hit the hardest by the COVID-19 lockdowns. In combination with the financial fragility that is typical of a small business, the reduction in consumer demand for all businesses resulted in mass employee layoffs and, in some cases, firm closure.[59] The negative consequences on small businesses were not just felt by owners and employees, but also by residents of the communities in which the businesses existed.[60] The closure of small businesses was mourned by communities, as they lost a source of goods/services as well as places for social interaction.

This thesis has identified the significant and positive correlation between an increase in walkability and an increase in small business receipts. Walkability not only has a positive impact on human health and the environment, but also creates opportunities for small businesses. When

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[58] "FACT SHEET: United States Bans Imports of Russian Oil, Liquefied Natural Gas, and Coal," The White House, March 8, 2022, https://www.whitehouse.gov/briefing-room/statements-releases/2022/03/08/fact-sheet-united-states-bans-imports-of-russian-oil-liquefied-natural-gas-and-coal/.

[59] Alexander W. Bartik et al., "The Impact of COVID-19 on Small Business Outcomes and Expectations," *Proceedings of the National Academy of Sciences* 117, no. 30 (July 28, 2020): 17656–66, https://doi.org/10.1073/pnas.2006991117.

[60] Jessica M. Finlay et al., "Aging in Place During a Pandemic: Neighborhood Engagement and Environments Since the COVID-19 Pandemic Onset," *The Gerontologist*, November 12, 2021, gnab169.

examined in the context of COVID-19, the importance of the findings in this thesis and subsequent policy implications becomes more concrete.

Appendix A

Definitions

5-Tier Retail = Retail

5-Tier Office = Information + Finance, Insurance, Real Estate, and Leasing +Public Administration

5-Tier Industrial = Agriculture, Forestry, Fishing and Hunting + Mining, Quarrying, and Oil and Gas Extraction + Utilities+ Construction + Manufacturing + Transportation and Warehouse + Wholesale Trade

5-Tier Service = Professional, Scientific, and Technical Services + Educational and Health Services + Other Services Expect Public Administration

5-Tier Entertainment, Accommodation, Food Services = Arts, Entertainment and Food Service

7-Tier Retail = Retail Trade

7-Tier Office = Information + Finance, Insurance, Real Estate, and Leasing

7-Tier Industrial = Agriculture, Forestry, Fishing and Hunting + Mining, Quarrying, and Oil and Gas Extraction + Utilities+ Construction + Manufacturing + Transportation and Warehouse + Wholesale Trade

7-Tier Service = Professional, Scientific, and Technical Services + Other Services Expect Public Administration

7-Tier entertainment = Arts, Entertainment and Food Service

7-Tier Education and Health = Educational and Health Services

7-Tier Public Administration = Public Administration

Appendix B

Formulas

(1) PercentEmpMix $= \frac{-E}{(\ln(N))} * 100$

$$E = \left(\frac{E7_{Retail}}{TotEmp}\right) * \ln\left(\frac{E7_{Retail}}{TotEmp}\right) + \left(\frac{E7_{Office}}{TotEmp}\right) * \ln\left(\frac{E7_{Office}}{TotEmp}\right) + \left(\frac{E7_{Industrial}}{TotEmp}\right) * \ln\left(\frac{E7_{Industrial}}{TotEmp}\right) + \left(\frac{E7_{Service}}{TotEmp}\right) * \ln\left(\frac{E7_{Service}}{TotEmp}\right) + \left(\frac{E7_{Entertain}}{TotEmp}\right) * \ln\left(\frac{E7_{Entertain}}{TotEmp}\right) + \left(\frac{E7_{Edu+Health}}{TotEmp}\right) * \ln\left(\frac{E7_{Edu+Health}}{TotEmp}\right) + \left(\frac{E7_{PublicAdmin}}{TotEmp}\right) * \ln\left(\frac{E7_{PublicAdmin}}{TotEmp}\right)$$

$N = \#\ of\ types\ of\ employment$ [61]

(2) PercentEmpHouseMix $= \frac{-A}{(\ln(N))} * 100$

$$A = \left(\frac{Households}{TotalActivity}\right) * \ln\left(\frac{Households}{TotalActivity}\right) + \left(\frac{E5_{Retail}}{TotalActivity}\right) * \ln\left(\frac{E5_{Retail}}{TotalActivity}\right) + \left(\frac{E5_{Office}}{TotalActivity}\right) * \ln\left(\frac{E5_{Office}}{TotalActivity}\right) + \left(\frac{E5_{Industrial}}{TotalActivity}\right) * \ln\left(\frac{E5_{Industrial}}{TotalActivity}\right) + \left(\frac{E5_{Service}}{TotalActivity}\right) * \ln\left(\frac{E5_{Service}}{TotalActivity}\right) + \left(\frac{E5_{Entertain}}{TotalActivity}\right) * \ln\left(\frac{E5_{Entertain}}{TotalActivity}\right)$$

$TotalActivity = Total\ Employment\ Count + Household\ Count$

$N = \#\ of\ activity\ categories\ (employment\ or\ housing)$ [62]

[61] In this case, N=7

[62] In this case, N=6

Appendix C

Stata Output

(1)

	WalkIn~x	PerCap~e	Percen~C	Median~e	Perce~le	Percen~t
WalkIndex	1.0000					
PerCapitaI~e	0.5772	1.0000				
PercentPOC	0.4081	0.0614	1.0000			
MedianAge	-0.0606	0.3110	-0.3123	1.0000		
PercentPop~e	0.1938	0.0737	0.2293	0.2445	1.0000	
PercentDem~t	0.5568	0.2437	0.6217	-0.1171	0.2921	1.0000

(2)

ReceiptsperEst~t	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
WalkIndex	39.15254	21.13531	1.85	0.065	-2.434801	80.73988
PerCapitaIncome	.0067386	.0015095	4.46	0.000	.0037685	.0097088
PercentPOC	1.464218	1.901417	0.77	0.442	-2.277144	5.20558
MedianAge	13.6782	7.37067	1.86	0.064	-.8248487	28.18126
PercentPopFemale	3.492793	11.98613	0.29	0.771	-20.09196	27.07754
PercentDemocrat	-1.745153	1.326607	-1.32	0.189	-4.355479	.8651728
_cons	-182.9693	583.6743	-0.31	0.754	-1331.448	965.5096

(3)

ReceiptsperEst~t	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
WalkIndex	77.28595	20.24327	3.82	0.000	37.45486	117.117
PercentPOC	4.165702	1.87435	2.22	0.027	.4776909	7.853713
MedianAge	34.49914	6.204797	5.56	0.000	22.29045	46.70783
PercentPopFemale	2.566633	11.54747	0.22	0.824	-20.15441	25.28768
_cons	-966.7923	566.3019	-1.71	0.089	-2081.06	147.4753

(4)

ReceiptsperEst~t	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
WalkIndex	79.50324	20.43456	3.89	0.000	39.2932	119.7133
PercentPOC	4.100088	1.889789	2.17	0.031	.3814617	7.818714
MedianAge	33.93916	6.364118	5.33	0.000	21.41619	46.46213
PercentPopFemale	2.407543	11.65056	0.21	0.836	-20.51782	25.3329
_cons	-939.8076	570.7003	-1.65	0.101	-2062.801	183.1861

(5)

ReceiptsperEst~t	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
WalkIndex	-306.3467	83.66488	-3.66	0.170	-1369.41	756.7164
PercentPOC	17.89801	7.22529	2.48	0.244	-73.90801	109.704
MedianAge	49.40064	7.970823	6.20	0.102	-51.87827	150.6795
PercentPopFemale	130.4649	41.41771	3.15	0.196	-395.797	656.7268
_cons	-7666.562	2131.394	-3.60	0.173	-34748.49	19415.36

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