ANNE T. AND ROBERT M. BASS CENTER FOR
TRANSFORMATIVE PLACEMAKING

Connecting people and places: **Exploring new measures of travel behavior**

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BROOKINGS

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Contents

Executive summary

The physical design of neighborhoods—from the density of their buildings to how they dedicate space for transportation—has far-reaching impacts on how people choose to travel. Reducing the physical distance between destinations and supporting proximity can allow for greater transportation choice. And with greater choice and proximity, people and places can realize a range of shared benefits, including industrial agglomeration, safer and more affordable transportation, and lower infrastructure costs.

Yet for decades, leaders across metropolitan America have overwhelmingly pursued land use and transportation policies that solely promote automobile use. Low-density neighborhoods, extensive highway construction, and a near-singular focus on measuring congestion have stretched the distances between where people live and where they travel. These policies have created an environment in which transportation is the top source of greenhouse gas emissions, vehicle costs are the second-largest household expense, and roadway injuries and fatalities are on the rise.

To capture the benefits of proximity, metropolitan American needs a refresh of its land use and transportation policies. The emergence of new digital tracking technologies offers a chance to use novel data sources and methods to measure local travel habits—including by trip purpose and trip distance—across multiple metropolitan areas at once. In turn, these measures can guide the development of a new set of outcomes focused not just on congestion mitigation, but on expanding transportation choices, promoting the health and well-being of people and the environment, and supporting economic growth and opportunity across more places.

This report analyzes neighborhood-level travel data across six metropolitan areas: Birmingham-Hoover, AL; Chicago-Naperville-Elgin, IL-IN-WI; Dallas-Fort Worth-Arlington, TX; Kansas City, MO-KS; Portland-Vancouver-Hillsboro, OR-WA; and Sacramento-Roseville-Arden-Arcade, CA. Our analysis reveals that:

- **People travel over 7 miles on average for every trip they take, but these distances vary widely across different metro areas and neighborhoods**. Neighborhood travel behavior—defined at the census tract level—is not monolithic. There are entire neighborhoods in which people travel under 4 miles on average for each trip they take. People in other neighborhoods can see their average trips exceed 10 miles.

- **Human-scale neighborhood designs lead to shorter distance trips.** Neighborhoods closer to the historic urban core, those that are designed with shorter blocks and more intersections per acre, and ones that consume less land overall tend to produce more trips under 3 miles. These human-scale design features also characterize older suburban neighborhoods developed before the automobile, where the average trip can be many miles lower than surrounding neighborhoods.

- **People traveling in automobile-oriented neighborhoods face longer trips overall, regardless of the trip's purpose.** Commuting to work represents only about 15% of all trips, but the average commute from emerging suburbs and exurbs exceeds 15 miles, while commuting from urban cores hovers near 10 miles. The relative differences are more pronounced for shopping and other regular errands, where emerging suburbs and exurban trips exceed 10 miles on average, double that of urban core trips.

- **Trip distances vary by income and race, reflecting patterns of racial and economic segregation.** People taking trips that start in lower-income neighborhoods tend to travel shorter distances than those taking trips that start in higher-income neighborhoods. The central location of many low-income neighborhoods largely explains these differences. However, these disparities disappear in more suburban areas, where travel distances are about the same for trips generated from low- and high-income neighborhoods alike. Likewise, trips starting in majority-minority suburban neighborhoods are more likely to cover longer distances than those originating from majority-minority neighborhoods in more centralized urban areas.

These travel patterns reveal how different land use characteristics can impact people's transportation behavior. Neighborhoods with automobile-oriented designs encourage long-distance trips, discourage transportation choice, and generate a range of societal costs. Meanwhile, proximity-focused neighborhoods directly counter the structural biases related to automobile-oriented development. The challenge moving forward, then, is how planners, engineers, real estate developers, financiers, and others can build neighborhoods that promote human-scale proximity and shift housing, employment, and other activity toward them. These findings point to three broad implications:

- **Transportation policy should use pricing and performance measurement to more actively support human-scaled neighborhoods.** This includes enacting congestion and vehicle miles traveled (VMT) fees, increasing the cost of parking, and reinvesting these revenues in human-scale transportation infrastructure. To guide future planning and investments, practitioners will need new performance measures focused on shared outcomes such as industrial growth and affordability, instead of congestion mitigation.

- **Land use policies should promote growth in neighborhoods that support proximity and spatial equity.** Current public policies often dissuade investment in and construction of denser, human-scale neighborhoods. To modernize this approach, local and regional governments should revamp outmoded zoning codes and adopt urban growth boundaries, land value taxes, and density-promoting financing techniques. Placemaking techniques such as reducing speed limits, improving streetscapes, and creating and maintaining welcoming, active public spaces can further attract people to live and work in human-scale neighborhoods.

- **America must electrify its vehicle fleet in order to mitigate climate change while new policies and practices are being developed.** Even as new policies are designed and adopted, it will take time to complete major real estate projects and redesign and redevelop our existing infrastructure. Given that driving will still be Americans' primary mode of transportation in the meantime, an all-electric vehicle fleet will be essential to hitting greenhouse gas reduction targets.

Introduction

Transportation touches every person, every day. Whether it's going to school or work, shopping at a market, or meeting with friends, we use roads, bike paths, sidewalks, and transit lines to connect the places we live to the places we need to go.

The distance and duration of our trips depend on the physical design of the neighborhoods where we live, work, and play. The closeness of homes and buildings, the speed limits and striping on our streets, the availability of public transportation, the presence of parks and trails, and the amount of available parking all influence the transportation choices and travel times we face. The connection between transportation choice and neighborhood design is tightly bound.

Ideally, communities are built to promote proximity, bringing housing and key destinations closer together. Greater proximity gives people transportation choice, as shorter distances can allow for walking, bicycling, or transit ridership as well as driving, depending on the design.[1] By enabling a range of transportation options to flourish, the benefits of transformative placemaking can take hold: more connected and creative economic ecosystems; safer, more accessible neighborhoods; more cohesive social environments; and more affordable and healthier travel habits.[2]

While the idea of choice is central to a competitive economy, many of the country's communities built in the past century have been designed with an almost-singular focus on lower densities, exclusive preference for the automobile, and congestion relief as the chief performance measure.[3]

The results of these design choices are clear. Over 91% of American households now have access to a vehicle, and total driving on the

country's roads exceeds 3 trillion miles per year.[4] All this driving makes transportation the country's top source of greenhouse gas emissions, leading to poor air quality and intensifying climate change.[5] The costs to own and maintain a car are the second-largest household expense after housing itself, hitting lower-income households especially hard.[6] Roadway fatalities are the second-leading cause of unintentional death across all ages.[7] And even though traffic mitigation is a core focus, highway congestion keeps getting worse.

The totality of these costs creates fresh urgency to reform how practitioners design and build neighborhoods and the transportation systems that serve them. Academics and other researchers have long understood how neighborhood design impacts transportation choices and travel distances.[8] But these findings have not always broken through to planners, engineers, real estate developers, and their peers. And even when they have, there is not a clear alternative measurement to congestion-focused transportation models.

This leads to the core question of this effort: What kinds of performance measures could help practitioners design neighborhoods and transportation systems that better capture proximity's benefits?

Digital technology offers an important breakthrough in this regard. The diffusion of satellite technology, location-based sensors, and mobile computing has created new sources of hyperlocal travel data. The resulting geolocation data—if appropriately anonymized—allows practitioners to assess how physical designs and travel behavior relate to one another, including the purpose, distance, and duration of trips. This is a major improvement on available public data that either strictly reports journeys to work or is conducted without the geographic granularity or frequency to answer core questions.

This paper demonstrates potential uses of such data, with travel distances serving as the foundation for a more place-based set of performance measures. Taking neighborhood-level data to measure transportation volumes for all trip purposes in six large metropolitan areas—Birmingham-Hoover, AL; Chicago-Naperville-Elgin, IL-IN-WI; Dallas-Fort Worth-Arlington, TX; Kansas City, MO-KS; Portland-Vancouver-Hillsboro, OR-WA; Sacramento-Roseville-Arden-Arcade, CA—presents a more complete picture of people's transportation behavior. Overall, average trips originating in many low-density neighborhoods can exceed 10 miles, leaving many travelers with little choice but to use a private car. But there is also evidence of an alternative. Neighborhoods designed at a human-scale—with closer physical proximity between destinations—host shorter-distance trips that encourage greater transportation choice.

The paper provides original evidence on how America's urban form leads to transportation inequities, while demonstrating how a proximity-focused paradigm could create more prosperous places. It begins by exploring the connection between transportation and urban form, the importance of physical proximity, and how newer data sources can overcome prior information barriers. It then demonstrates the potential uses of such data by analyzing neighborhood travel patterns and establishing the clear connection between design choices, household and employer characteristics, and the distances people travel. The paper concludes with implications for transformative placemaking strategies.

The relationship between urban form and distance

The ability to reach key destinations is a defining feature of every neighborhood. This concept—known as "accessibility" in planning and economic practice—proposes that the more places a person or business can reach within a given travel time, the more valuable a starting location will be.[9] People consistently show a preference to travel no more than 30 minutes for any purpose, which makes destinations reachable within that time frame especially valuable, as evident in real estate assessments.[10]

One implication of this principle is that the technologies available in any era strongly shape urban form. Whereas older neighborhoods used building density, short blocks, and shared civic spaces to support travel by foot or horse, the introduction of engine-powered vehicles—from interurban streetcars to today's automobiles—significantly stretched the distances one could cover in 30 minutes. This dramatic increase in travel speeds enabled a new kind of neighborhood, one that promised larger houses and green space per person without sacrificing access to key destinations. Troublingly, developers often worked in concert with residents to segregate these neighborhoods by race, as evidenced by restrictive racial covenants and formal government redlining.[11]

This 20th century model also introduced a new set of assumptions about how places would look, feel, and function. First, people would need vehicles; longer distances required faster travel speeds to reach key destinations, making walking or bicycling less convenient, as well as less safe. Second, lower-density neighborhoods would require more infrastructure per capita. Vehicles are larger than people, so communities would need to build and maintain wider roads, plus longer water pipes and electricity lines per capita, and more space for parking. Third, these new neighborhoods would consume more land per capita than older cities and towns.

With over half of all Americans living in auto-centric neighborhoods (both in central cities and suburbs), these places now represent the dominant and prevailing pattern of development across the country.[12] This has led to rising transportation-related environmental impacts, significant infrastructure costs per capita, more hours sitting in traffic, and sizable costs to American families, who have the highest vehicle ownership rates in the world. And, too often, auto-centric neighborhoods end up degrading accessibility, even by car.[13] Most troublingly, these low-density neighborhoods are not designed to maximize the value that proximity can bestow.

Why proximity matters

Economists and planners have long espoused the benefits of bringing people and opportunities closer together, or increasing ***proximity*** between the two. Even when accounting for faster travel speeds in private cars, there are significant benefits of an urban form that promotes shorter-distance travel:

- **Proximity supports agglomeration, helping to grow industries and regional economies.** Research continually finds that economies benefit when workers and firms in certain industries locate near one another (or cluster), saving travel time and promoting greater knowledge exchanges.[14] Designing cities and suburbs to enable proximity—including the development of compact, diverse, and pedestrian-orientated neighborhoods—can allow agglomeration economies to take hold.[15] This is true in downtowns, innovation districts, dense urban enclaves, small-town main streets, as well as in mixed-use suburban developments, all of which work to foster greater access to workers, customers, and business peers.[16]
- **Proximity requires less infrastructure per capita, reducing fiscal burdens on communities.** Infrastructure is consistently one of the largest categories of public expenditure, requiring a mix of local taxes and direct user fees to fund construction, operation, and maintenance of roads, transit, water infrastructure, and even telecommunications.[17] When cities and suburbs consume less space, it reduces a community's investment burden, creating financial flexibility and improving a region's economic competitiveness in the process.[18]

- **Proximity enables more modal choice, making transportation more affordable and enhancing mobility for all.** People prefer to walk, bike, ride a scooter, or take certain transit at shorter distances, meaning the closer people and destinations are, the more likely they are to consider these modes.[19] Attracting more people to walk, bike, and take transit can enable households to save money relative to driving. Bringing people and destinations closer together also promotes mobility for people of all ages, especially the young and old who cannot drive.

- **Proximity is essential to hitting carbon targets and developing more resilient places.** Proximity facilitates trips via non-driving modes, which, in turn, reduces the country's carbon footprint.[20] Low-density neighborhoods not only require more auto use, but they also lead to numerous other environmental impacts and costs, including higher per capita stormwater runoff and energy use resulting from more extensive building footprints and impervious surface cover.[21] In contrast, denser, human-scale neighborhoods better manage and conserve the natural environment, absorbing stormwater runoff and consuming less energy per capita.

- **Proximity allows for safer streets and a healthier population.** Transportation-related fatalities are on the rise, making transportation the most dangerous daily activity for most people.[22] Designing streets for proximity should mean slower vehicle speeds and more bicycle, micromobility, and pedestrian infrastructure, which creates a safer environment for everyone. Human-scale proximity also offers more opportunities for social interaction, which researchers suggest can improve individual and collective mental health.[23] Finally, non-driving modes require greater physical activity, which positively impacts physical health.[24]

The importance of new geolocation data

To realize the benefits of greater proximity, practitioners need data that enables them to better measure and assess communities' transportation behavior and land use demands, including where, when, and why people travel between places. They then need to compare such data against supply-side considerations, including the location and use of buildings and transportation assets.

Traditional transportation behavior data doesn't tell us enough. Supply-side data—including public data about the exact locations of employment, housing, infrastructure assets, real estate pricing, and even digital zoning data—offers some helpful information, but local-scale annual federal transportation data sources focus strictly on journey-to-work habits, which are only about 15% to 20% of all trips.[25] Private data providers measure driving rates on specific highway segments—most often seen as congestion data within mobile mapping applications—but this data offers an incomplete picture by omitting non-driving trips. And while some metropolitan areas run independent, expensive, and infrequent traveler surveys to understand trips for non-work purposes, those surveys are incomparable to peer regions.

Constrained by the available data, decisionmakers too often measure the wrong things. For example, transportation planners rely on congestion data to measure whether volume is outstripping capacity—or what's known as level of service (LOS) measures—which then informs the metro-wide congestion indices often cited in the media.[26] However, LOS and congestion indexes fail to inform practitioners about where travelers start their trips, where they end, or why they're traveling in the first place. The tangible goal is high travel speeds, but there is no recognition of the interplay between physical design and travel behavior, nor is there a recognition of broader economic, social, or environmental goals. Effectively, these measures devalue proximity.

The rise of geolocation data offers a solution. By using a mix of GPS, cell phone, and other digital positional technologies to track exactly where and when people travel—and doing so consistently across the country—geolocation data can measure transportation volume at the neighborhood scale. Open-access bikeshare data, for example, uses the bicycle's sensors to show where and when people start and end their bike trips.[27] Expanding this data universe to include trips by all modes is now possible, evidenced by a fast-growing array of academic research with access to various geospatial sources, from mobile phones to cars to credit cards.[28] In essence, geolocation data can capture realized travel demand.[29]

Still, these emerging data sources come with at least three major concerns. The first is privacy, as the creators of geolocation data can relay sensitive information to third parties. Academics and media outlets have done excellent framing and reporting on the issue, leading to international conversations about how to protect privacy while still enabling data collection for public good.[30] The second issue is price—geospatial data is expensive to procure, creating barriers to fiscally constrained communities and nonprofit researchers. The third issue is potential sample bias and the need to calibrate and validate the results against real-world activity and amongst representative populations.

These concerns notwithstanding, new, anonymized geolocation data is incredibly valuable in helping practitioners better understand transportation behavior and land use demand. This information can then inform how to design and build communities that reduce costs, expand access, and improve human and environmental health and resiliency.

Methodology

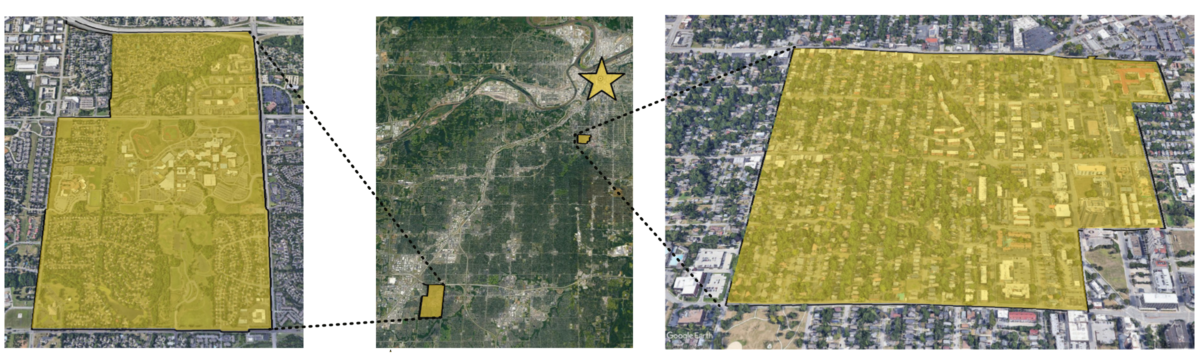
This project combines geographically granular travel data and other local economic, social, and land use data to explore neighborhood-level transportation behavior within a given set of metropolitan areas. In this report, we examine a set of baseline trip data, including the total number of trips to and from each neighborhood, the distance and duration of these trips, and the purpose of these trips (e.g., commuting to work or shopping). The geolocation data firm Replica provided data for a typical Thursday in fall 2018 (September through November), which avoids more extreme day-of-week and seasonal variation.

The explosion in digital transportation data from geolocation sources—including individual traveler records from GPS devices, mobile phones, and other technologies—makes this analysis possible. While there are numerous private data providers that track travel behavior, we rely on trip data from Replica, a geolocation data provider that models trip movement based on de-identified mobile location data from several different companies, population data from the U.S. census, and other field data from local government agencies.[31] Replica models their travel data to represent the entire population of a given metropolitan area, meaning this paper analyzes all trips taken within the study areas over a single day.

To protect privacy, Replica uses de-identified data and applies de-identification measures in its data platform. This minimizes the risk of re-identifying specific trips or people. Replica's "synthetic" data closely matches aggregated statistics, but is not intended to match any specific underlying person in the original data. Replica does not attempt to re-identify individuals from its data sources, and its terms of use prohibit the Brookings Institution from doing so as well. In particular, Replica does not join data sources through sensitive data. Independent models are built on different data sources in order to abstract-out identifying details of any given individual before combining with other data sources.

We analyze travel patterns at the neighborhood level, aggregating trends up to larger county, metropolitan, and other geographic designations. "Neighborhoods"

Figure A. Tracts in the Kansas City, MO-KS metropolitan area



Population: 3,916
Total Jobs: 1,576
Land Area: 1.4 sq mi

★Downtown

Population: 3,072
Total Jobs: 1,287
Land Area: 0.3 sq mi

are our base level of local geography, corresponding to census tracts. We combine neighborhood travel across all tracts in several different metropolitan statistical areas (MSAs), as defined by the Office of Management and Budget. In this report, we examine travel patterns across six different MSAs: Birmingham-Hoover, AL; Chicago-Naperville-Elgin, IL-IN-WI; Dallas-Fort Worth-Arlington, TX; Kansas City, MO-KS; Portland-Vancouver-Hillsboro, OR-WA; Sacramento-Roseville-Arden-Arcade, CA. These include a combined 5,257 census tracts. Table 1 includes additional details about each metro area.

For the purposes of this analysis, we exclude any trips that do not start and end within the same metropolitan area.[32] We also do not subdivide trips by transportation mode (private vehicles, transit, or bicycle). We also subdivide the metropolitan areas by their counties, using a Brookings classification scheme of: urban core (counties that are at least 95% urbanized); mature suburbs (75% to 95% urbanized); emerging suburbs (25% to 75% urbanized); and exurbs (less than 25% urbanized).

To complement the Replica data and more clearly investigate travel patterns, we have also constructed an extensive database containing census-tract-level economic and built environment data. Additional information on this database and other methods used in this analysis are available in a downloadable appendix.

Table 1. Various characteristics, six metropolitan areas

Metro Area Name	Population	Employment	Tracts	Land area (sqmi)	Weighted Population Density
Birmingham-Hoover, AL	1,082,561	420,538	246	4,497.7	1,385.2
Chicago-Naperville-Elgin, IL-IN-WI	9,488,961	3,961,691	2,196	6,213.7	8,854.2
Dallas-Fort Worth-Arlington, TX	7,189,384	2,963,188	1,312	8,686.4	4,246.4
Kansas City, MO-KS	2,106,632	891,946	528	7,246.4	2,404.9
Portland-Vancouver-Hillsboro, OR-WA	2,417,931	973,887	491	6,677.6	4,820.4
Sacramento--Roseville--Arden-Arcade, CA	2,291,738	691,461	484	5,087.2	4,787.9
All 6 metro areas	**24,577,207**	**9,902,711**	**5,257**	**38,409**	**5,848.5**

Source: Brookings analysis of census data.

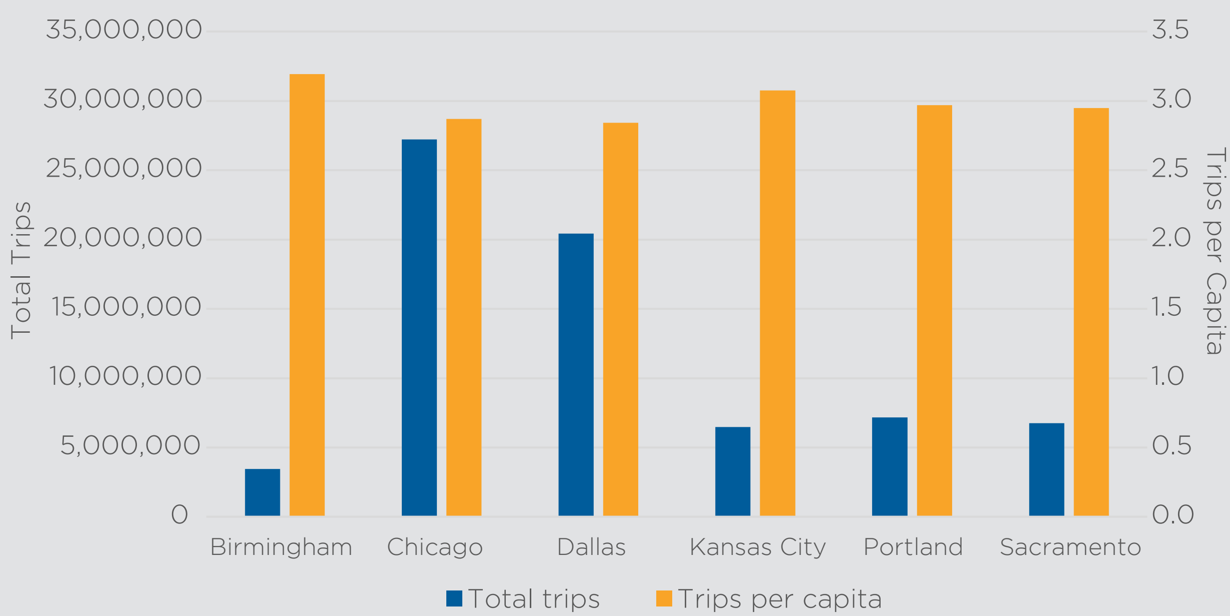
DEFINING TRIPS

Measuring where people travel and the number of trips they take is essential in understanding how economies function in a given place. Trips not only help explain individual travel habits, but also reveal how transportation volumes deviate across whole regions. In this report, we define a trip as a single journey made by an individual between an origin and a destination that does not include intermediate stops. For example, if an individual travels from their house (origin) to a store (destination), that would represent one trip. If the individual then traveled to work afterward, that would represent a separate trip, and so on.

For the purposes of this paper, ***we define trips strictly through the lens of the origin***. This means we associate trips with the neighborhood where they start (a specific census tract), the distance those trips cover, and the time those trips take. We count all trips as one-way trips. For example, a trip from home to work counts as one trip, while a trip from work to home counts as a separate trip. This report analyzes four types of trip purposes: trips to ***work***, trips to ***school***, trips to the traveler's ***home***, and trips to all ***other*** places.

We strictly use origins—and omit a destination perspective—for two reasons.

Figure 1. Total trips and trips per capita, six metropolitan areas



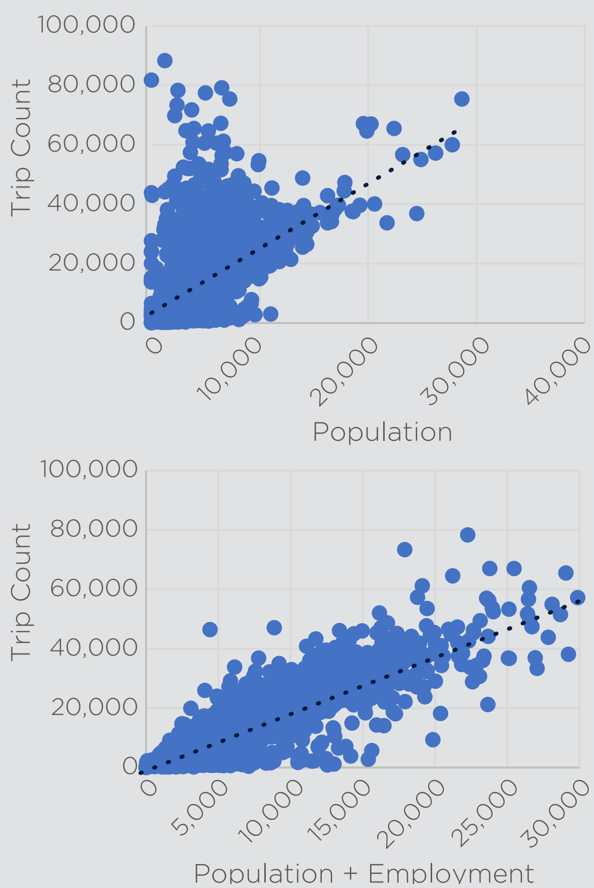
Source: Brookings analysis of Replica data

First, origin and destination distances and durations tend to equal one another in each tract. Second, focusing strictly on the origin side ensures we do not double-count trips within each metro area.

Based on this definition, Replica reports that residents, businesses, and visitors generated 71.5 million trips on a typical weekday across the six metro areas. Although the total number of trips varies considerably from person to person, these aggregate numbers equal about three trips per day per person (Figure 1). These per capita numbers are also relatively consistent with 2017 survey data for the whole country.[33]

Critically, it is the combination of population *and* employment that helps predict and explain trip variation, both at a metro area and neighborhood level. Figure 2 demonstrates how tract-level trip counts correlate with three other variables of interest: neighborhood population, neighborhood employment, and the combination of population and employment. Employment, especially in combination with population levels, is a powerful predictor of total trip counts. There is a 0.9 correlation between total trips and the number of people living and working in a given neighborhood.

Figure 2. Total trips by tract, cross-tabulated against population, employment, and population plus employment, six metropolitan areas



Correlation Coefficient (r-squared) (left to right): 0.48; 0.79; 0.90

Source: Brookings analysis of Census data

Findings

1. People travel over 7 miles on average for every trip they take, but these distances vary widely across different metro areas and neighborhoods.

Measuring how far people are traveling—and how much time their trips take—reveals how proximate activities are at both the metropolitan and neighborhood scales.

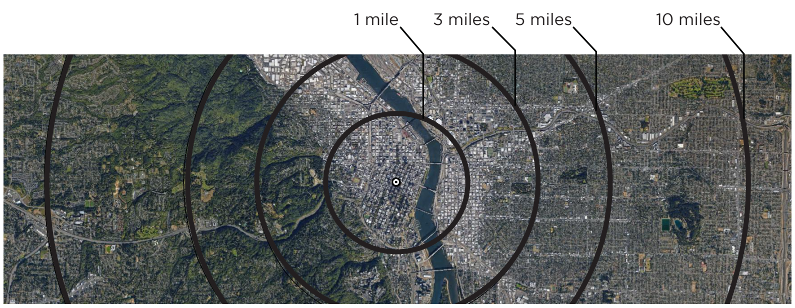
Across all six metro areas, people travel 7.3 miles on average for every trip they take on a typical weekday.[34] Table 2 compares the average weekday trip distances in each metro area. The 2-mile difference between Portland on the low end and Kansas City on the higher end may seem minor, but the differences add up quickly. If residents take about three trips on average each day, it's reasonable to expect a Portland resident would travel about 6 to 7 fewer miles per day than a peer in Kansas City. Across a whole year—estimating about 250 non-holiday weekdays—it would mean the average Portland resident would travel roughly 1,600 fewer miles than the average Kansas City resident. For drivers, these could lead to substantial cost savings, and even more for those who switch to other modes. [35]

Table 2: Average trip conditions, six metropolitan areas

Metro Area	Total Trips	Average Distance (mi)	Average Duration (min)	Average MPH	Daily Mileage per Capita
Birmingham	3,456,412	7.5	12:13	36.8	23.8
Chicago	27,227,092	7.3	18:54	23.3	21.0
Dallas	20,442,486	7.5	12:35	35.5	21.3
Kansas City	6,478,170	8.2	13:50	35.0	25.2
Portland	7,178,101	6.2	16:00	23.3	18.4
Sacramento	6,759,309	6.8	13:07	31.1	20.1
6-Metro Totals	**71,541,570**	**7.3**	**15:29**	**29.3**	**21.3**

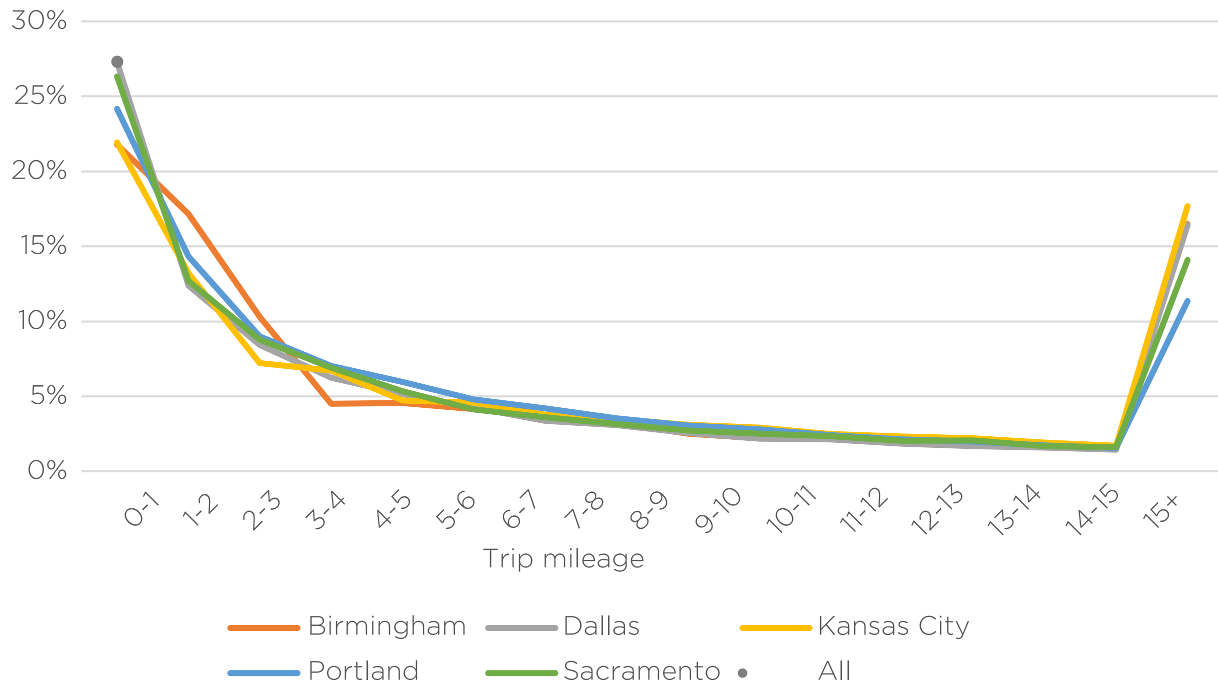
Source: Brookings analysis of Census data.

Figure B. Distance bands from downtown Portland, OR



Note: These are Euclidean distances from the centroid of the largest job center in downtown Portland.

Figure 3. Share of all trips by trip mileage, six metropolitan areas



Source: Brookings analysis of Replica data

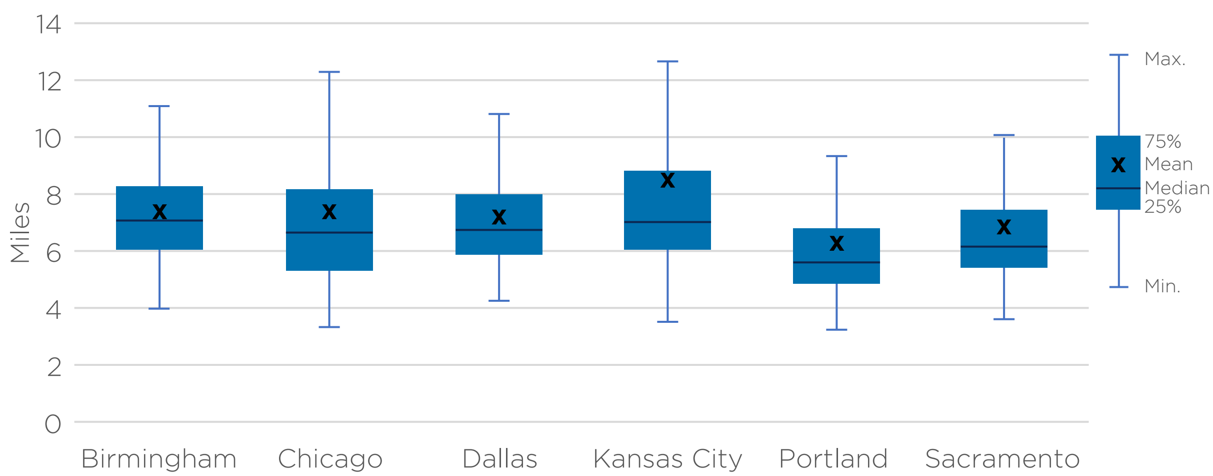
Although the average trip exceeds 7 miles, most people's trips are much shorter (Figure 3). Over 50% of all trips in Chicago, Dallas, Portland, and Sacramento fall under 4 miles; in Kansas City, 49% of trips fall below that threshold. Millions of trips don't even stretch a mile, ranging from 22% of trips in Kansas City to 30% in Chicago.

What's explaining the longer average distance? A few very long trips are pulling up metro-wide averages. Across all six metro areas, over 20% of trips travel more than 10 miles, and 15% of trips in Chicago, Dallas, and Kansas City exceed 15 miles.

Variation also appears when looking at the average trip distance in each neighborhood. Figure 4 shows the average distance for trips starting in the 5,011 neighborhoods (or census tracts) across the six metro areas. It's not uncommon to find individual neighborhoods where the average trip can be as short as 4 or 5 miles, but there are also neighborhoods where the average trip exceeds 10 miles. Effectively, each metro area has neighborhoods where distances can be double the length of another local neighborhood. At its core, this confirms how each metropolitan area includes neighborhoods designed for—or which have evolved to support—different kinds of trip types.

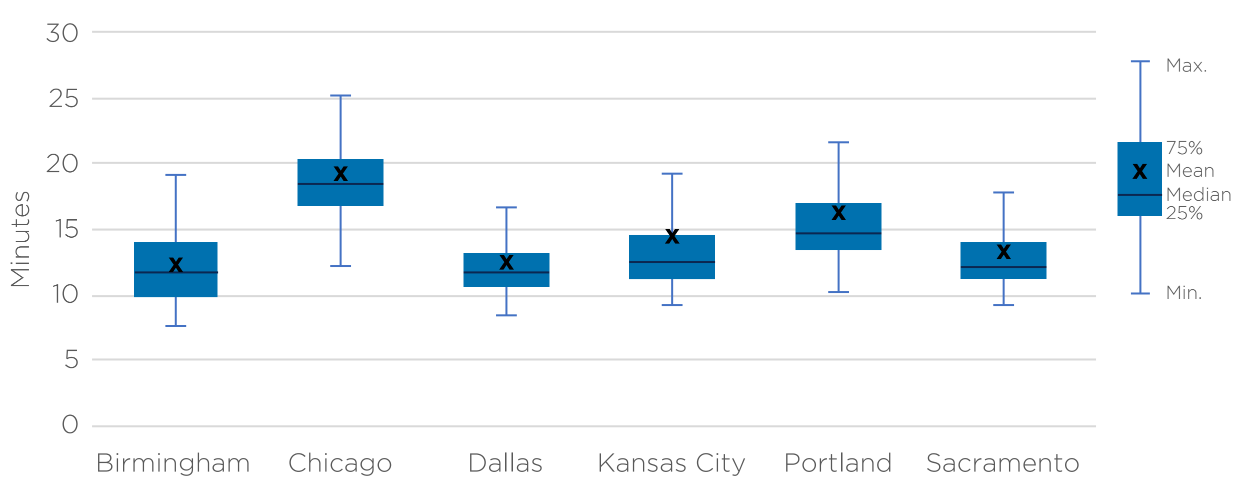
Covering longer distances can be costly and inconvenient for many people, but how fast (or slow) these trips are matters too. People face a wide range of average trip times and speeds depending on the particular metro area and neighborhood in which they are travelling. In general,

Figure 4. Average trip distances, by metropolitan area's tracts, six metropolitan areas



Source: Brookings analysis of Replica data

Figure 5. Average trip duration, by metropolitan area's tracts, six metropolitan areas



Source: Brookings analysis of Replica data

people in metro areas with a higher share of shorter-distance trips tend to experience slower travel times. This distinction reflects the design of the country's transportation and land use systems. Shorter-distance trips are more likely to lead individuals to take a bus, train, bicycle, or walk—each of which tends to travel at a slower speed than private automobiles. Shorter trips are more likely to use local streets which mandate slower speed limits. Finally, trips in crowded locations are more likely to confront congestion for longer portions, which can slow speeds.

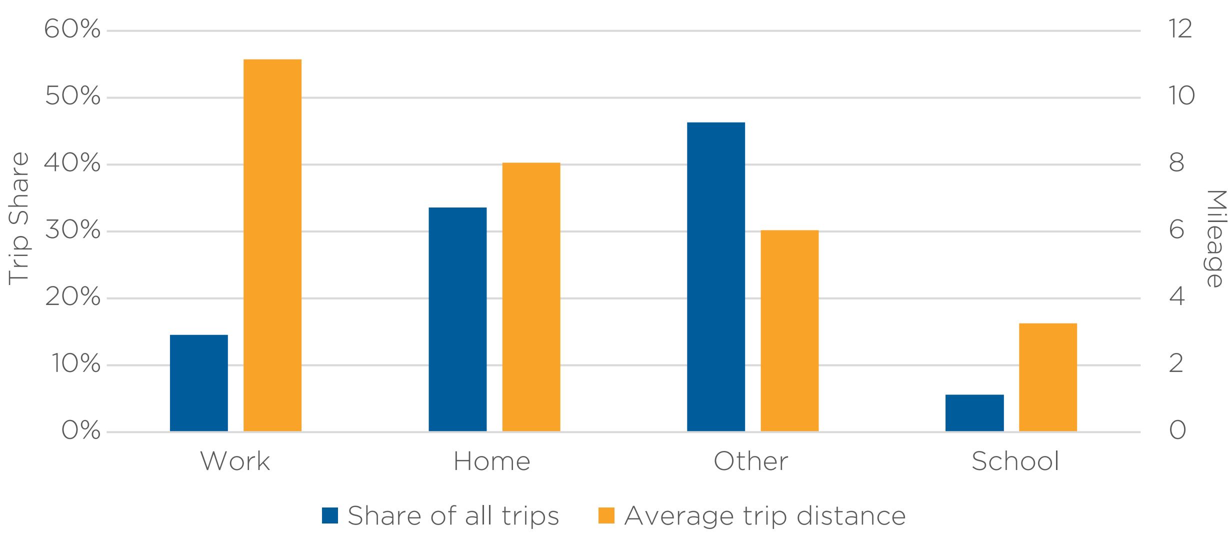
Figure 5 demonstrates how trip durations vary across neighborhoods within the same metro area. Trips can only take a few minutes in some cases, but in others, they can last 20 minutes or more. This can make a big difference for people as they traverse regions. For instance, average travel speeds are significantly faster in most Dallas, Kansas City, and Sacramento neighborhoods. Their range is also relatively tight; the average speeds in 75% of neighborhoods fall within 3 to 4 mph of one another. On the other hand, the average travel speeds in Chicago and Portland neighborhoods are noticeably slower.

Slower speeds are not necessarily a negative. While slow speeds can lead to longer total travel times, they also lead to safer streets for all people and can attract foot traffic for businesses. In the case of Portland and Chicago, it also could be related to simply driving on more local streets (with slower speed limits) than the other three metro areas.

2. People traveling to and from work cover the longest distances, but those traveling in lower-density neighborhoods face longer trips overall—regardless of purpose.

People travel for a variety of reasons, and this report analyzes four types of trip purposes: trips to work, trips to school, trips back home, and trips to all other places. While the total number and average distance

Figure 6. Share of all trips and average trip distance, by purpose, six-metropolitan-area average



Source: Brookings analysis of Replica data

Table 3. Average trip distance, by purpose, six metropolitan areas (in miles)

Metro area	Trip purpose			All trips
	Work	Home	Other	
Birmingham	11.8	9.3	4.8	7.5
Chicago	11.9	8.0	6.1	7.3
Dallas	11.1	8.3	6.1	7.5
Kansas City	11.2	8.4	7.7	8.2
Portland	8.9	6.8	5.2	6.2
Sacramento	10.4	7.6	5.7	6.8

Source: Brookings analysis of Replica data.

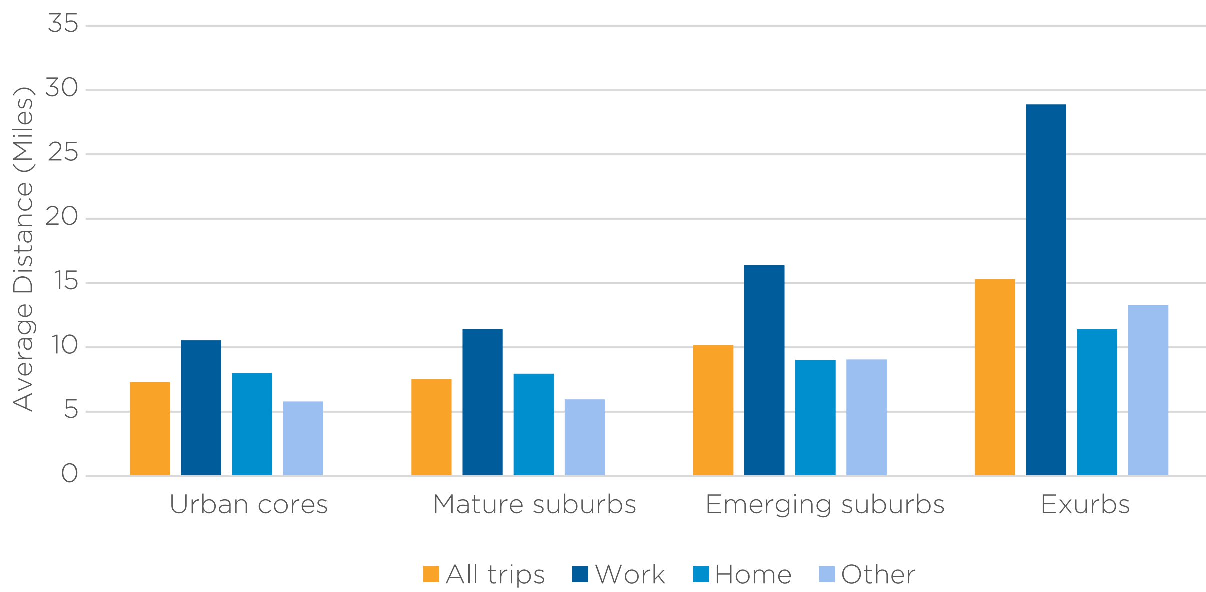
of these trips can vary across the six metro areas, people traveling to work—or what the Census Bureau considers a commute—consistently face the longest trips.

The distances are so long, in fact, that commuting is disproportionately impacting the total distances people travel, as Figure 6 shows. While work trips represent only 14% of all trips, their average distance exceeds 11 miles. By contrast, trips in the "other" category (which includes shopping and recreation) constitute 46% of all trips but cover an average distance of only 6 miles. These trends are similar across all six metro areas (Table 3).

Within each metro area, people travel for a variety of purposes, and the distances they cover differ markedly depending on the specific type of neighborhood. At the county level, for instance, people travel longer distances—regardless of purpose—as they get farther from the urban core (Figure 7).[36] People traveling in emerging suburbs cover 9.4 miles on average for "other" trips, compared to 5.8 miles on average for the same types of trips in urban core counties.

But it's not just the location of these trips; the purpose of trips also has a substantial impact on travel behavior. Commutes are consistently pushing residents to travel longer distances than other activities, which helps explain why rush hour can feel so claustrophobic on the country's roads and rails. Across the six metro areas analyzed,

Figure 7: Average trip distance, by purpose and county geography, six-metropolitan-area average

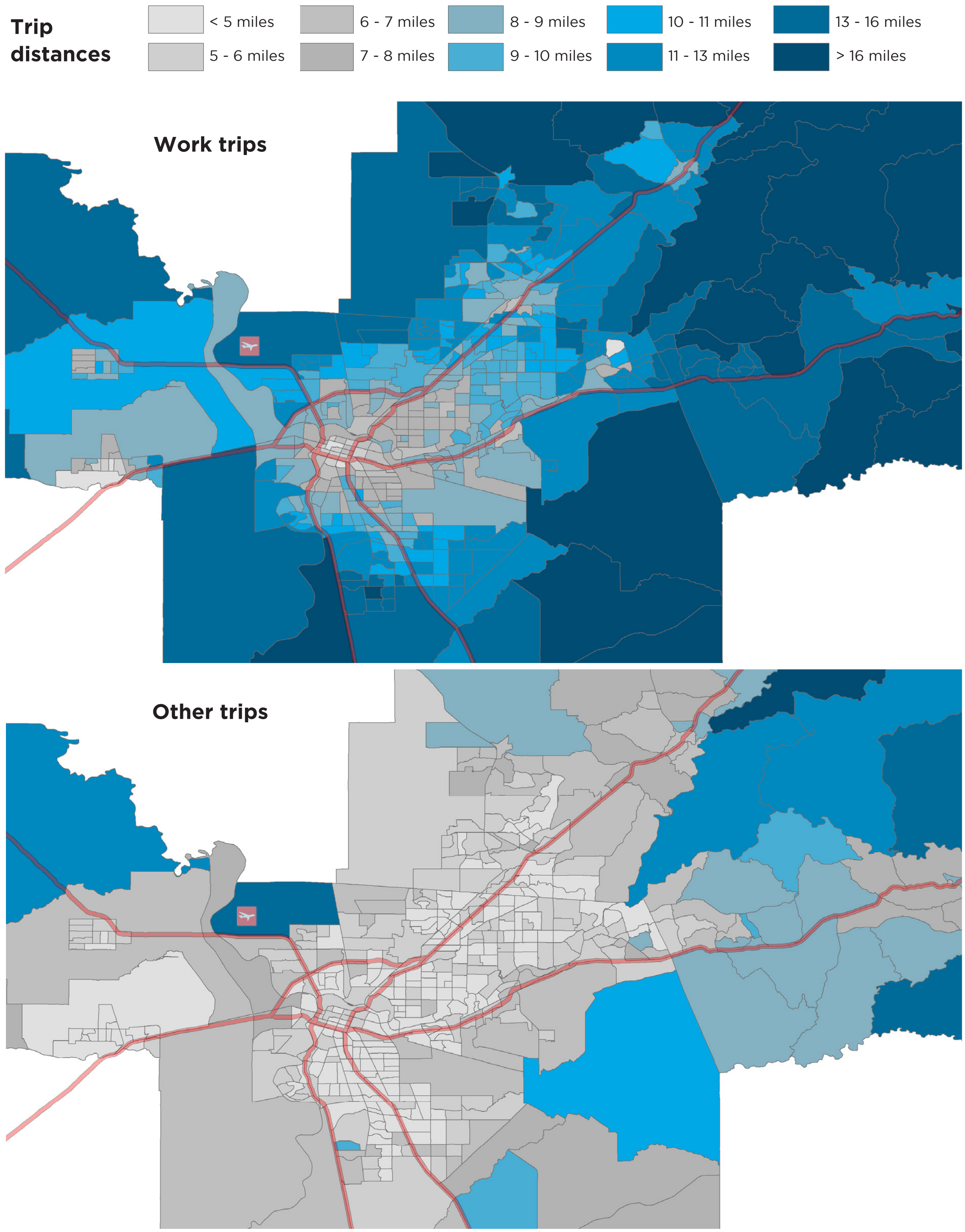


Source: Brookings analysis of Replica data

work trips amount to about 110 million miles per weekday (or 22% of all daily mileage). These distances are growing even longer as more American jobs and households locate in the suburbs, and as suburb-to-suburb commuting—as opposed to suburb-to-downtown commuting—continues to increase.

Mapping distances for work and other trips in any of the six metro areas underscores this point, including Sacramento (Figure 8). The two-pane map purposely maintains the same distance scale, making it clear how much longer trips to work are for essentially every tract in the metro area when compared to other trips. But there's also a clear distance advantage enjoyed by residents of the more central Sacramento neighborhoods. Many of the neighborhoods' average commutes don't exceed 8 miles, while tracts just a few miles away may experience commutes hitting 13 miles or more. Likewise, trips for other purposes are often under 6 miles when they start in Davis to the west, the city of Sacramento, or through Folsom to the east.

Figure 8: Average trip distance, by work and other purposes, Sacramento MSA census tracts



Source: Brookings analysis of Replica data.

3. Human-scale neighborhood designs lead to shorter-distance trips.

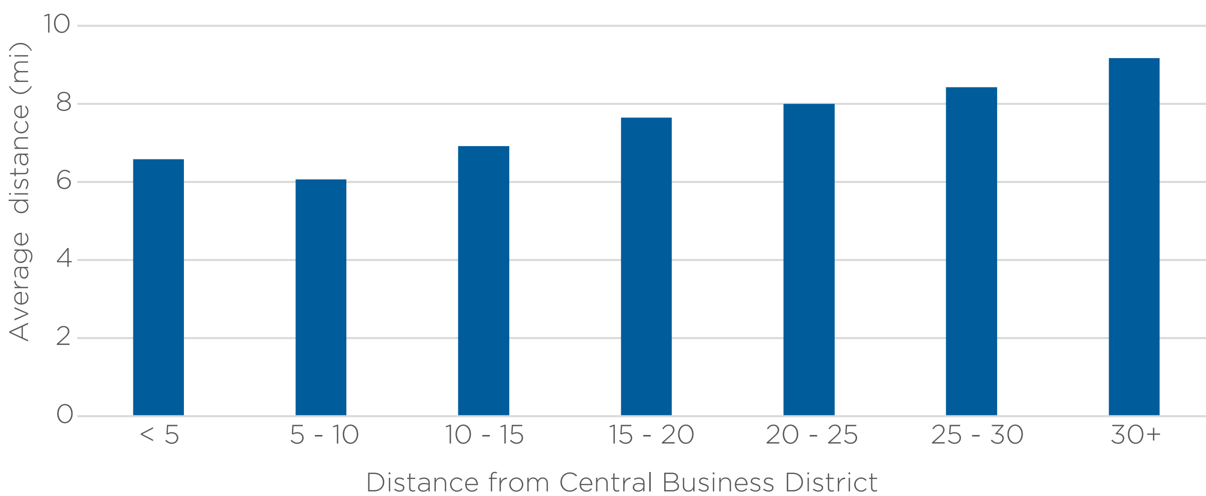
Urban theory has long contended that designing places for density—from larger buildings to tighter street grids—can promote shorter-distance trips.[37] Applied research has also regularly confirmed this theory. Our analysis finds similar results, but with some important caveats.

Looking across the six metropolitan areas, a clear pattern emerges. People traveling from neighborhoods closer to the central business districts (CBD)—or what most call downtowns—consistently cover shorter distances, compared to those traveling from neighborhoods farther from the historic urban core.[38] Figure 9 demonstrates this effect, bucketing neighborhoods by their distance from the CBD and the average distance of trips originating in those distance bands. For the most part, trip distances continue to creep up as one moves outward.

There is one notable exception: People tend to travel longer distances from neighborhoods that are 5 miles or less from the CBD. With large clusters of high-paying jobs, regional amenities, and highway and transit lines emanating out from the urban core, it's not surprising that trips starting in these central neighborhoods tend to fan out across entire metro areas. This is a reflection of the density of regionally significant amenities such as major employers and cultural institutions. The same overall pattern—a "downtown spike" in trip distances, followed by an immediate drop in surrounding neighborhoods, and then a gradual growth in trip distances farther from the CBD—is common across the six metro areas analyzed.

Chicago embodies this narrative (Figure 10). People traveling from The Loop, Chicago's world-renowned CBD, often take longer trips. However, people traveling from nearby neighborhoods (10 miles or fewer from The

Figure 9: Average trip distance, by tract's distance from central business district, six metropolitan area totals



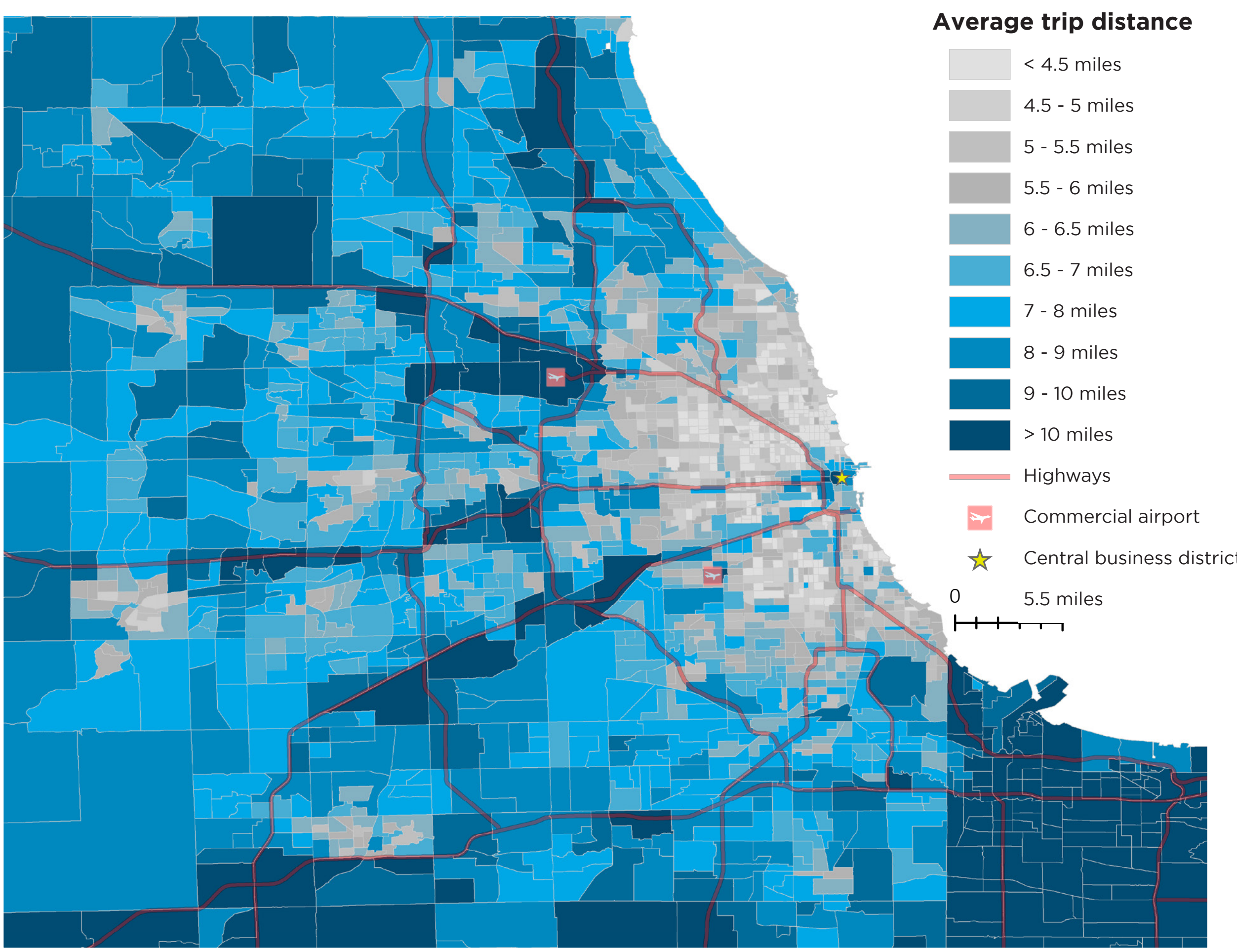
Source: Brookings analysis of Replica data

Loop) have an average trip distance of no more than 6 miles. Finally, people gradually cover longer distances as they get farther from the city of Chicago. A notable exception to this trend are the shorter trips people take to and from a mix of historic towns—Aurora, Joliet, and Wheaton—and streetcar suburbs that have dense street grids and smaller-lot housing similar to Chicago's central neighborhoods.

Surrounded by a sea of sprawling development, these older suburban neighborhoods have become transportation islands: collections of neighborhoods that confirm how human-scale design principles can incentivize shorter-distance trips for residents and businesses alike. Portions of Richardson (outside Dallas), Davis (outside Sacramento), and Vancouver (outside Portland) also fall into this category. The shorter-distance trips within these walkable, suburban neighborhoods suggest some of the benefits possible within polycentric metropolitan areas, or regions not anchored by just one traditional downtown and central city.

Several factors explain why some neighborhoods have shorter (or longer)

Figure 10: Average trip distance, by tract, Chicago metropolitan area



Source: Brookings analysis of Replica data

trips. Across all six metropolitan areas, using a range of regression models, the same set of variables consistently have a significant effect on the average trip distance. Neighborhoods farther from the CBD and with more land area (measured in square miles) tend to generate longer-distance trips. Conversely, neighborhoods with higher population densities—excluding the unique characteristics of downtown office hubs—tend to generate shorter-distance trips.

There are also several variables of interest related to the built environment, in which impacts vary by place:

- **More roadway intersections per square mile** (a measure of street grid density) leads to shorter-distance trips from Chicago, Dallas, and Portland neighborhoods, but there is no significant effect in Birmingham, Kansas City, and Sacramento. These results confirm how building for proximity in those metro areas can lead to transportation behavior that promotes transportation choice.

- **Longer street blocks** (a sign of lower building density) lead to significantly longer-distance trips in Chicago, Dallas, Portland, and Sacramento, but the opposite effect in Kansas City and no significant effect in Birmingham. Similar to street grid density, these findings confirm shorter blocks can promote more activity within short distances.

- **The share of all homes that are detached** has insignificant effects in all metro areas except Dallas and Portland, where a higher share leads to shorter average trips. This confirms how single-family housing doesn't have to mean longer trips. More important is how dense those houses are and how tight the street grid is where they're located.

The overall effect is clear: Metropolitan land use and physical design can influence how far people travel, but those impacts vary based on a range of other demographic and economic conditions, along with several other variables not yet tested. *[To view complete model results, see the Appendix]*

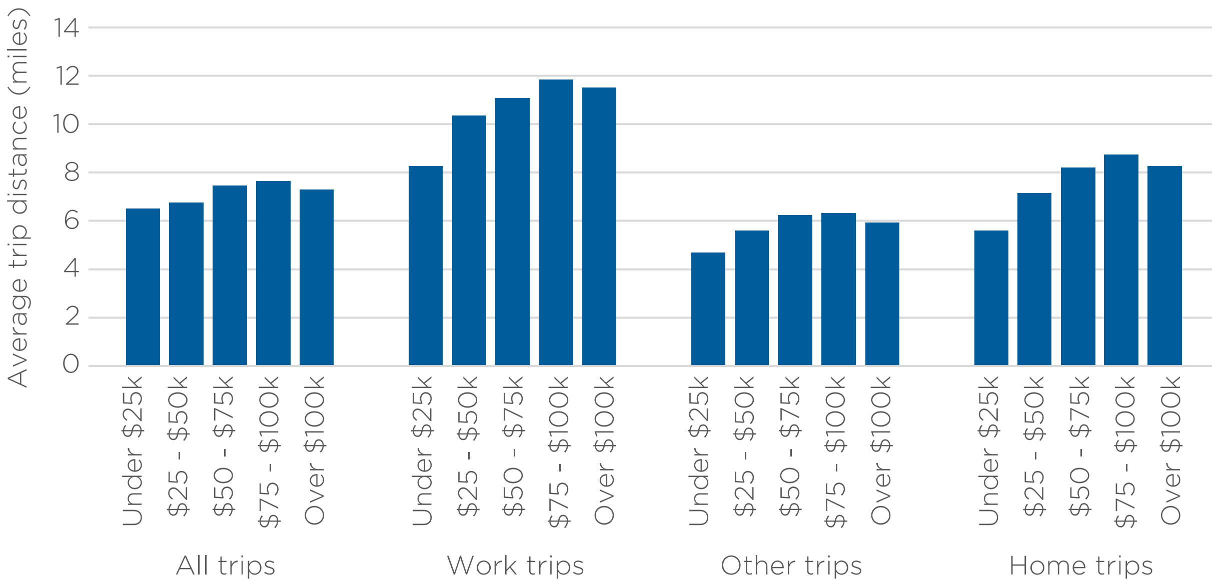
4. Trips distances vary by income and race, reflecting patterns of racial and economic segregation.

Across all six metro areas, people tend to travel longer distances if they're farther from the urban core and in neighborhoods with automobile-oriented designs. These geographic effects impact all types of neighborhoods, across all income levels, races, and ages.

For example, consider median household income (Figure 11). Trips starting in neighborhoods where the annual median income falls below $25,000 cover an average distance of 6.5 miles, which is roughly a mile less than trips starting in neighborhoods where the annual income exceeds $75,000. Those differences are even more pronounced when looking at work trips; these mileage differences for the average trip can quickly add up, too, equating to 1,000 fewer annual travel miles per adult worker.

However, these differences are reduced once controlling for a neighborhood's distance from the central business district (Figure 12). Within the first 15 miles of the CBD, neighborhoods of all income levels tend to generate similar trip distances. More than 15 miles from the CBD, though, these patterns become inconsistent. Since 75% of all lower-income neighborhoods are located within 10 miles of the CBD in these six metro areas, geography is a major explanation for why local trips starting in lower-income neighborhoods cover shorter distances than those from higher-income neighborhoods.

Figure 11. Average trip distances, by tract annual median income and trip purpose, six metropolitan area average



Source: Brookings analysis of Replica data

Table 4: Average trip distances, by distance from central business districts, six metropolitan areas

Distance from CBD	Majority minority			All other tracts		
	Tracts	Population	Average distance	Tracts	Population	Average distance
< 5 miles	248	749,678	6.5	489	1,793,709	6.6
5 - 10 Miles	408	1,533,188	6.0	850	3,937,392	6.1
10 - 15 Miles	232	1,095,442	6.9	809	4,050,778	6.9
15 - 20 Miles	87	449,088	7.8	512	2,630,514	7.6
20 - 30 Miles	118	487,855	8.2	726	3,866,753	8.2
> 30 Miles	52	233,273	7.1	706	3,749,537	9.3
All Tracts	1,145	4,548,524	6.7	4,092	20,028,683	7.4

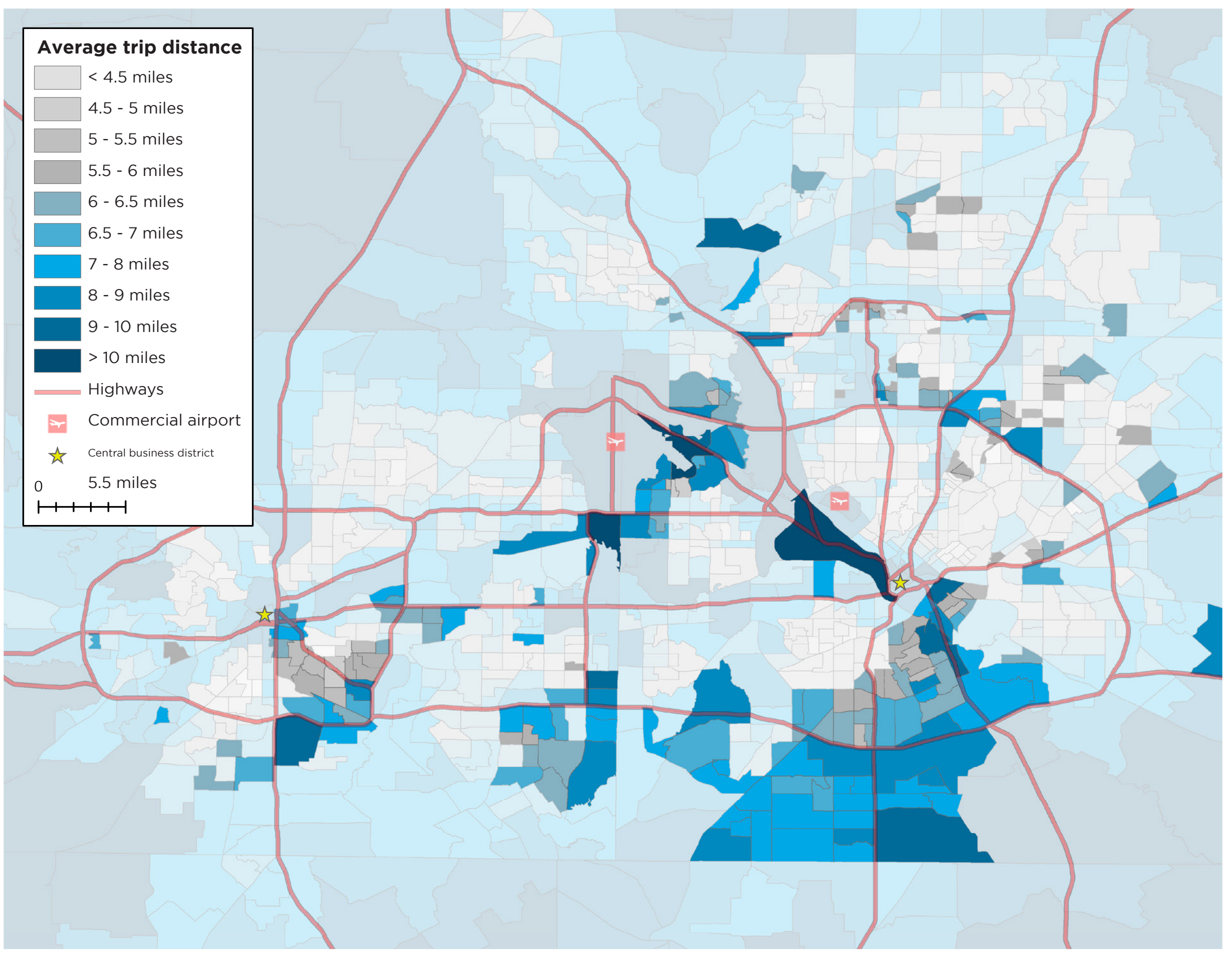
Source: Brookings analysis of Replica and Census data.

Source: Brookings analysis of Replica data.

Metropolitan geography has the same impacts when assessing travel distances by race. The average trip distance starting in majority-minority tracts is 6.6 miles. The average trip starting in all other tracts, however, is 7.4 miles. Subdividing those tracts based on their distance from the CBD erases most of the gap (Table 4). Similar to income differences, 75% of majority-minority tract residents live within 15 miles of a CBD, leading to shorter distances for trips starting in those neighborhoods.

These differences are apparent when looking at specific metro areas (Figure 12). In metropolitan Dallas, for example, trips starting in the majority-minority neighborhoods near central Fort Worth and Dallas often cover the same short distances expected of their non-majority-minority neighbors. But many of the metro area's majority-minority neighborhoods are farther from the center cities. It's not a surprise to see longer-distance travel starting in the neighborhoods located outside Interstates

Figure 12: Average trip distances, majority-minority tracts, Dallas MSA census tracts



Note: Majority-minority tracts are in full color; other tracts faded.
Source: Brookings analysis of Replica and census data.

20, 820, and 635 and Texas 183 (the horizontal oval of highways encircling Fort Worth and Dallas).

One area in which demographics do impact average travel distances is age, and specifically school-age children. School trips are by far the shortest distance trips by purpose, meaning the number of children in a neighborhood will significantly impact overall travel distances. Advanced statistics confirm the significance of a younger population on trip distances. By contrast, the share of a neighborhood population that's older than 65 has little impact on average distances when controlling for other variables. This could indicate that as the U.S. population continues to age, communities will need to grapple with accommodating the travel needs of older adults who can no longer drive.

WILL COVID-19 CHANGE DEMAND FOR HUMAN-SCALE NEIGHBORHOODS?

The COVID-19 pandemic is a landmark event for the country's public health and economic prospects. At the time of publication, COVID-19 is on track to be one of the country's leading causes of death in 2020.[39] Attempting to minimize the threat via business closures has forced tens of millions of people to lose their jobs. Meanwhile, stay-at-home orders and collective fear have transformed people's physical movements, leading to cleaner air and a general urge for more safe, personal space.[40]

Automobile-oriented neighborhoods do have certain advantages during pandemics like this one. Neighborhoods with single-family homes and private green space offer plenty of recreational opportunities for all ages. Households with a vehicle can still travel for essential services such as groceries without encountering people along the way. Meanwhile, denser neighborhoods across the country often do not have enough sidewalk space for residents to move safely. Transit—a lifeblood in dense cities and for many essential workers—can struggle to attract riders during times of social distancing.

However, denser neighborhoods are not at a complete disadvantage during a pandemic. They offer walking and bicycle access to jobs and other services, allowing for peace of mind. As cities such as Oakland, Calif. have demonstrated, it's possible to restrict automobile use on urban streets in order to create safe places for people to walk, bike, and play outside.[41] Likewise, lower demand for parking allows restaurants—including those in Dallas' Bishop Arts District—to repurpose space for outdoor seating.[42]

Human-scale neighborhoods will still offer their expansive benefits once people feel safe in crowds again. Just as cities survived polio scares a century ago, the COVID-19 pandemic will pass, but the benefits of agglomeration, social interaction, lower emissions, and more affordable infrastructure will remain.

Implications

Building neighborhoods to promote proximity—or bringing people and destinations closer together—can unlock sweeping economic, social, and environmental benefits. Industrial agglomeration can flourish. Public infrastructure costs are lower. Travel can be cheaper, more environmentally friendly, and safer for all.

Based on this report's findings, however, those are not the kind of neighborhoods America has built. The average travel distance in the six metropolitan areas studied was 7.3 miles per trip. Even the average trip distance in metropolitan Portland—the second-densest of the six areas—reaches 6.2 miles.

Critically, average trip distances grow as neighborhoods move further from the downtown core, have a looser street grid with longer blocks, and consume more land overall.[43] In other words: By building neighborhoods strictly for the automobile, we have limited transportation choice and undermined proximity.

Decades of low-density, outward growth have led to ever-growing distances between where people live and where they work, shop, and socialize. These longer distances directly impact individual travel and lifestyle choices. For example, someone who lives in a walkable neighborhood but works in a suburban office park may feel the need to own a car if transit service doesn't meet their commuting needs. This situation is common: Over 43% of jobs are located at least 10 miles from traditional central business districts, meaning most individuals must confront suburban commutes.[44] Maybe

most important, though, is that most people live in neighborhoods that they define as suburban.[45]

The prevalence of automobile-oriented designs leaves only so much residential, commercial, and industrial real estate available in walkable, bikeable, transit-accessible neighborhoods.[46] In many metro areas, a mismatch between the supply of these human-scale communities and the demand for them is evidenced by their high prices, which in turn makes it difficult for the most economically disadvantaged households and businesses to simply relocate into them.[47] Likewise, many human-scale neighborhoods are older, which often makes construction more expensive, demands longer timelines, or both.[48] Finally, even if a person or business locates in a human-scale neighborhood, they will still need to connect to all the opportunities in automobile-oriented locations. It will take a significant number of years to build over these designs.

Just as troubling is the fact that too many neighborhoods do not have the infrastructure to promote transportation choice. For much of metropolitan America, the majority of jobs cannot be reached by fixed-route transit within 90 minutes.[49] Most neighborhoods, even in central cities, continue to have no dedicated on-street or pathway bike infrastructure.[50] Some suburban communities do not maintain sidewalk infrastructure of any kind.[51] This makes car ownership the only sensible option for people who cannot safely travel more than a few miles by bus, train, bicycle, or walking—or simply do not have the time. These distances certainly help explain why there are more registered vehicles in America than adults over the age of 18, the highest rate among peer developed countries.[52]

Such automobile bias supports a dangerous spatial cycle. Designing for cars inherently pushes people and destinations farther apart. That geographic separation forces people into vehicles, which increases the demand for real estate and roadways to better accommodate those vehicles. This creates a cycle known as “induced demand,” in which more automobile-oriented infrastructure such as wider highways only leads to more driving, which leads to more congestion. Subsequently, the default response is to build more roads and automobile-oriented development to handle the demand.[53]

Add it all up, and the structural bias toward car ownership becomes an outright bias against economic equity, environmental sustainability, social cohesion, fiscal resilience, and economic competitiveness. Since vehicles are expensive to own and maintain, lower-income households face an impossible choice between spending too much on a car or losing time and key opportunities by relying on other transportation modes. The country’s sky-high vehicle ownership rates create high transportation emissions per capita. Our extensive driving habits and highway infrastructure also isolate people, making it harder to exercise and reducing chances to interact with others. Driving infrastructure is also expensive to maintain, which is a significant burden for fiscally constrained municipalities. Finally, automobile-oriented development does not maximize support for business clustering and industrial agglomeration.

Fortunately, this paper’s findings also point toward a design-based response that already exists.

Neighborhoods designed for proximity consistently have a positive and significant relationship with shorter-distance trips, confirming how denser designs influence transportation behavior. There are neighborhoods in all six metropolitan areas studied—from central Sacramento to older towns on Chicago's suburban fringe—where the average trip is shorter than 5 miles. Denser, human-scale neighborhoods in those six metropolitan areas also experience even larger shares of trips that travel no more than 1 or 2 miles, surely a reason for the shorter overall average distances.

These proximity-focused neighborhoods directly counter the structural biases related to automobile-oriented development. Human-scale designs give people cheaper, cleaner alternatives to private driving, promote more social interaction and physical activity, require less infrastructure, and support industrial clusters and higher worker productivity.[54] These are the exact benefits long espoused by placemaking professionals, from Jane Jacobs to Jan Gehl. This paper's study of geolocation travel data proves that proximity-focused designs work.[55]

The challenge moving forward, then, is how planners, engineers, real estate developers, financiers, and others can build neighborhoods that promote human-scale proximity and shift housing, employment, and other activity toward them. These findings reveal three broad implications:

1. Transportation policy should use pricing and performance measurement to more actively support human-scale neighborhoods.

Transportation is more than just engineering. The infrastructure society builds and the policies that govern use of it send a clear signal to households and businesses about where to locate and how to travel. With little variation, federal, state, and local officials overseeing transportation policy have largely focused only on accommodating vehicles, which has led to sprawling real estate development and underinvestment in human-scale neighborhoods. This was always a normative choice, not simply an engineering preference.

To capture the shared benefits of proximity, it's imperative that society modernize transportation policies to respond to and better accommodate demand for human-scale neighborhoods.

This process begins with more explicit pricing of driving and its related impacts. As it stands, driving is heavily subsidized; states collect gas taxes from driving on all roads and disproportionately spend the revenue on high-speed roadways that promote far-flung, automobile-oriented neighborhoods.[56] Governments' highway spending relies on indirect revenues such as income and sales taxes, hiding direct costs.[57] Most local governments mandate private construction of parking spaces based on real estate conditions, while hourly street parking in some downtowns can cost less than a one-way transit fare.[58]

Enacting pricing policies that promote proximity's benefits can begin to address negative externalities. States and localities should institute vehicle miles traveled (VMT) fees to charge people more directly for their travel during congested periods and the use of more expensive infrastructure, as well as to fiscally balance where people live and what roads they use. Transitioning to VMT fees also allows gas taxes to become carbon taxes against greenhouse gas (GHG) emissions, where they can be tuned to better capture gasoline's environmental impacts.[59]

As an intermediary step, local governments can institute congestion pricing in their densest neighborhoods. Based on consistent research findings, local governments should also raise hourly parking rates and eliminate mandatory parking minimums in order to promote more sustainable transportation habits. Critically, VMT fees, gas taxes, and parking revenues should be invested back into bicycle infrastructure, transit capacity, and modern sidewalks. The combination of more expensive driving and more alternative infrastructure will send a clear market signal to residents and businesses.

Likewise, solving roadway congestion cannot—and should not—be the primary goal of any transportation system. Local, state, and federal leaders must shift away from a measurement schema that continues to disadvantage proximity-focused designs and fails to focus on people.[60] Traditional level of service (LOS) measures do not consider the distances someone will travel; there is a big difference between a 2-mile congested drive and a 10-mile smooth drive. Even worse, the overwhelming response to poor LOS performance is to build more lane miles to relieve the congestion. This only doubles-down on the structural bias toward automobiles, incentivizing more outward development. LOS also implicitly promotes faster driving speeds, which leads to more dangerous roads.[61] Finally, LOS feeds into the endless cycle of induced demand, which means measuring *for* congestion actually leads *to even more* congestion.

This paper's findings confirm the need for a new kind of performance measurement system. This system should prioritize a different set of outcomes—not just congestion, but shared outcomes such as economic prosperity—and measure progress against them at the neighborhood and metropolitan scales. That includes new supply-side measures such as accessibility indexes, which would measure the number of key destinations someone can reach by multiple modes within certain distances and times. The system should also accurately measure travel behavior through new geolocation data and ensure that data is publicly accessible. Finally, it should include a broad range of complementary datasets—from industry location data to sidewalk quality to property values—to compare how infrastructure supply, neighborhood conditions, and travel behavior interrelate. Future pieces will explore these performance measures in greater depth, including their implementation.

2. Land use policies should promote growth in neighborhoods that support proximity and spatial equity.

Decades of automobile-oriented development have created an impressive amount of physical infrastructure and public policies that outright dissuade investment in and construction of denser, human-scale neighborhoods. Greenfield development is typically cheaper per acre and faster than similar projects in older neighborhoods, and invariably cheaper than brownfield development. Metropolitan fragmentation—the existence of multiple municipal and country governments in one place—incentivizes peripheral governments to promote outward growth. Too much metropolitan zoning permits only large-lot homes or single-use commercial buildings, making it essentially illegal to build denser, more mixed-use communities in many areas. And this is just a sampling of a deck that is stacked against human-scale neighborhoods.

Policy reforms can flip these preferences. Impact fees can shift the cost burden to develop peripheral land to new residents, and urban growth boundaries such as those in Portland can outright curtail it. Land value taxes can compel property owners in dense locations to build more or sell to someone who will. Financing regulations such as transit-oriented development credits and the facilitation of mixed-use developments could incentivize more infill development. In addition to new transportation funds flowing to pedestrian, biking, and transit infrastructure, minimum residential lot sizes and single-family zoning can be outlawed. These options—and many more like them—already exist.

Such reforms can help metropolitan America bring more development to the neighborhoods that naturally support shorter-distance travel. Some metropolitan areas already have these neighborhoods. Older neighborhoods tend to have a dense street grid, multistory buildings, civic spaces within walking distance, and a reliance on a small set of corridors to travel longer distances. These kinds of neighborhoods are like nutrient-rich soil just waiting for cultivation. In this case, placemaking techniques such as reduced speed limits, new cultural programming, and rebuilt gathering spaces can attract people to live and work in these neighborhoods—a kind of place-based gardening to bring the urban fabric back to full bloom. Critically, these tactics can work within communities of all sizes, as Main Street America and Project for Public Spaces' toolkit, *Navigating Main Streets as Places,* details.[62]

However, there is still a need for more neighborhoods designed for proximity. It will take decades and require large amounts of financial capital to repurpose automobile-oriented designs for more human-scale proximity. Evidence is clear from suburbs attempting such massive change, including Tysons Corner, Va. Some older city and suburban neighborhoods may also struggle to attract investment and initiate change. And when residential, commercial, and industrial demand does flourish in proximity-focused neighborhoods, the experience in some high-growth coastal markets has shown that gentrification and displacement can follow.[63] Forward-looking development strategies—such as building enough in walkable neighborhoods to keep up with demand and keep prices lower—will prepare for such negative outcomes.

This should be read as an affirmative message. There is demand for human-scale neighborhoods, so now is the time to build more of them and ensure they're accessible to all.

3. America must electrify its vehicle fleet to allow for time to implement new policies while still addressing climate change.

Even with a proposed shift in transportation and land use policy, these findings are a sobering reality. The average distances most people travel, combined with sky-high auto ownership rates, means many American households cannot immediately give up their cars.

For the next few decades, many automobile-oriented neighborhoods will probably see few changes. The houses and roads are already built, and neither one is a flexible asset. Homeowners have a vested interest in keeping their housing values high, which means keeping restrictive land use regulations in place. It'd be foolish to expect people to simply abandon their houses and accumulated wealth, and the public will expect governments to maintain roads as long as people use them.

Single-family homes could get updated to become multifamily units and roads could be modified to promote transit, biking, and even denser buildings. But those changes will be expensive and likely piecemeal, and they would not eliminate the longer-distance trips that low-density neighborhoods incentivize.

This fact is especially disconcerting because driving is a serious environmental stressor. Transportation is already the country's top source of GHG emissions. It's also the sector where emissions continue to rise, due to a combination of more total driving and growth in intercity travel. While flying is the worst polluting mode per passenger mile, light-duty vehicles and trucks combine to produce over 80% of all transportation-sector GHG emissions.[64]

How does the country clean up the transportation sector if we can't get people out of cars? Climate models consistently show that the planet only has a few decades left to avoid the most catastrophic effects of global climate change.[65] Considering the U.S.'s outsized contribution to global GHG emissions, we cannot do our part without change in the transportation sector.

The natural response should be a two-part strategy. The first phase is electrifying the vehicle fleet. There are challenges to such a feat: the sustainability of mining rare earth minerals for batteries, installing ample recharging infrastructure, bringing renewable electricity sources online, modernizing electricity grids, and making new electric vehicles (EVs) affordable for all. The EV transition can update a depreciating asset, as the overall vehicle fleet turns over roughly every 15 to 25 years. New cars will fill American roads no matter what, so it's imperative they're as clean as possible.

If the EV transition is effective and fast enough, it will buy time for the strategy's second, concurrent phase around neighborhood reinvestment. If the country can avoid the most catastrophic impacts of climate change, it will allow for more time for the United States and other electrifying countries to make other resilience-focused changes. In particular, the EV transition will give metropolitan America time to build more neighborhoods that promote proximity and overcome structural bias against non-driving.

Here is where a grand bargain must be struck. EVs are clearly the preferred environmental option for driving's future, but driving's prices must reflect its climate and economic impacts while neighborhood and infrastructure development actively promotes human-scale neighborhoods. Local governments and their state and federal partners must see the interconnected, phased strategy and commit to it. It took the country almost a century to get to where we are now; we must be sober enough to realize the negative impacts will not be undone in a decade.

Conclusion

Almost a century since the construction of the first highways, the United States has become an assemblage of different types of places. The country was once characterized by dense city neighborhoods and small towns, but during the last century's building boom, newer designs such as suburban office parks, gated communities, and large-lot retail centers came to dominate. The result is a metropolitan landscape where most people now live and work far from human-scale neighborhoods, and instead spend most of their time in places designed to cater to the automobile.

Using new types of geolocation data, we can see how urban form impacts transportation behavior, giving us another data point to confirm how theory translates to practice. Our analysis confirms that denser, human-scale neighborhoods generate shorter-distance trips, which enables greater transportation choice and demonstrates the kind of physical proximity that unlocks economic, social, and environmental benefits. But the findings also underscore the consequences of so much outward, low-density growth over the prior century. Metropolitan America will be stuck with the consequences of automobile-oriented design for some time.

However, the data also introduces exciting new possibilities. The combination of physical design, economic indicators, and the newest sensor-based technology allow for novel analyses related to long-standing issues, from neighborhood segregation and zoning reform to modal usage patterns and real estate valuations. The onus rests with researchers and practitioners to revisit old questions and raise new ones to build more prosperous and sustainable places.

Appendix: Model results

The following six models are ordinary least squares (OLS) multiple regressions. The dependent variable is the average distance traveled (*OriginMeanDist*) on all trips starting within a given census tract. The independent variables are conditions within the same tract. An exact data dictionary for the independent variables follows the model results.

We ran independent models in each metro area with the exact same model specifications. Hence, the number of observations equals the number of populated tracts in each metro area. Each model has significant explanatory power per the r-squared values, but the explanatory values differ from metro area to metro area. Critically, not all conditions have the same effect on the average distance traveled, either in direction or magnitude. These likely relate to a broad set of different conditions in each metro area, many of which are not yet accounted for within the model. For now, the paper body focuses strictly on the significance of each variable and their direction.

This project will continue to refine this model over time. The final report will also add text, refine the layout, and include exact data sources.

Data dictionary

Variable	Name
CBDv2	Distance from Central Business District (mi)
landarea	Tract Land Area (sqmi)
blocksize	Average Block Size
intersectiondensity	Density of Intersections
BAOrHigher	Share of Adults with BA or Higher (%)
MedianIncomeK	Median Household Income ($1,000s)
JobsAll	Total Jobs
TotalPop	Total Population
ZeroVehiclesShare	Share of Population without Access to a Vehicle (%)
popdensity	Population Density (persons / sqmi)
Pop19AndUnderPercent	Share of Population Aged 19 or Younger (%)
Pop65AndOverPercent	Share of Population Aged 65 or Older (%)

PovertyRate	Poverty Rate (%)
OriginTripsTot	Total Trips Starting in the Tract
SingleDetachedShare	Share of Homes that Are Single Detached (%)
JobDensityAll	Job Density (jobs per sqmi, enhanced Bass measure)
Airports	Airport in Tract? (Dummy)
AsianPercent	Asian Percent of Population (%)
BlackPercent	Black Percent of Population (%)
OtherMinorityPercent	Other Non-White Population (including Hispanic) (%)

Dependent variable:						
	OriginMeanDist					
	Chicago	**Dallas**	**Kansas City**	**Portland**	**Sacramento**	**Birmingham**
	(1)	(2)	(3)	(4)	(5)	(6)
CBDdist	0.071***	0.034***	0.333***	0.131***	0.053***	0.117***
	(0.006)	(0.004)	(0.024)	(0.009)	(0.006)	(0.018)
landarea	0.041***	0.025***	0.064***	0.005**	0.013***	-0.011
	(0.007)	(0.003)	(0.006)	(0.002)	(0.002)	(0.007)
blocksize	0.024***	0.010***	-0.031***	0.004***	0.008***	0.001
	(0.003)	(0.001)	(0.005)	(0.001)	(0.001)	(0.004)
intersectiondensity	-0.002***	-0.003***	0.003	-0.002***	0.001	-0.001
	(0.0004)	(0.0005)	(0.003)	(0.001)	(0.001)	(0.002)
sharebahigher	0.739	-1.641***	0.703	-1.074**	-1.106*	-1.248
	(0.509)	(0.301)	(1.534)	(0.506)	(0.666)	(1.353)
MedianIncomeK	-0.012***	0.005***	-0.007	0.007*	0.012**	0.007
	(0.003)	(0.002)	(0.011)	(0.004)	(0.005)	(0.010)
jobtot	0.0004***	0.0001***	0.001***	-0.00001	0.0001*	0.0003***
	(0.00002)	(0.00001)	(0.0001)	(0.00004)	(0.0001)	(0.0001)
TotalPop	0.0003***	-0.00001	0.0003**	-0.0002***	-0.0001	0.0002**
	(0.00003)	(0.00002)	(0.0001)	(0.00004)	(0.0001)	(0.0001)
ZeroVehiclesShare	-2.474***	-1.468*	2.209	1.818	0.657	-1.131
	(0.797)	(0.769)	(3.305)	(1.155)	(1.995)	(2.987)
popdensity	-0.00002***	-0.0001***	-0.001***	-0.00004*	-0.0001***	-0.0002
	(0.00001)	(0.00001)	(0.0001)	(0.00002)	(0.00004)	(0.0002)

share19andunder	-4.427***	-1.618***	-8.506***	-3.900***	-1.944	-1.546
	(1.001)	(0.620)	(3.127)	(1.146)	(1.788)	(2.321)
share65over	1.358	0.126	-2.879	-1.422	-0.403	0.631
	(0.933)	(0.618)	(2.987)	(1.012)	(1.084)	(2.784)
povrate	2.648***	-0.961**	1.430	-0.877	1.089	0.808
	(0.758)	(0.478)	(2.288)	(1.039)	(1.290)	(1.806)
OriginTripsTot	-0.0002***	0.00000	-0.0003***	0.00004***	0.00001	-0.0001**
	(0.00001)	(0.00001)	(0.00005)	(0.00001)	(0.00002)	(0.00002)
SingleDetachedShare	0.132	-1.394***	-0.635	-0.709**	-0.434	-0.064
	(0.283)	(0.153)	(0.805)	(0.333)	(0.511)	(0.854)
JobDensityAll	-0.00000	0.0001***	0.0001	-0.00001	0.0001*	0.0001
	(0.00001)	(0.00001)	(0.0001)	(0.00001)	(0.00004)	(0.0001)
Ports				-0.912	6.070***	1.349
				(1.249)	(1.604)	(1.610)
asianshare	-0.107	-0.471	-0.769	-0.830	-0.457	-0.569
	(0.621)	(0.369)	(3.926)	(0.797)	(0.782)	(6.450)
blackshare	0.105	0.545***	0.259	3.556***	2.127	-0.581
	(0.250)	(0.186)	(0.879)	(1.360)	(1.398)	(0.671)
OtherMinorityPercent	-1.173**	-0.577	6.473**	-5.307***	-1.595	-0.464
	(0.558)	(0.391)	(2.692)	(1.037)	(1.308)	(2.650)
Constant	8.303***	8.702***	8.865***	7.345***	6.430***	6.096***
	(0.504)	(0.266)	(1.285)	(0.536)	(0.767)	(1.154)
Observations	2,189	1,308	515	489	484	245
R^2	0.577	0.736	0.780	0.838	0.647	0.548
Adjusted R^2	0.573	0.732	0.772	0.831	0.632	0.508
Residual Std. Error	2.159 (df = 2169)	0.941 (df = 1288)	2.795 (df = 495)	0.926 (df = 468)	1.485 (df = 463)	1.556 (df = 224)
F Statistic	155.786*** (df = 19; 2169)	189.125*** (df = 19; 1288)	92.474*** (df = 19; 495)	121.059*** (df = 20; 468)	42.448*** (df = 20; 463)	13.604*** (df = 20; 224)
Note:						*p<0.1; **p<0.05; ***p<0.01

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